ATTACHMENT

DECLARATION

I, Shuichi Tomita, a professional translator, declare that to the best of my knowledge and belief the following is a true translation into the English language of the document, Japanese Laid-Open Patent Application Publication No. 2000-338116 published on May 17, 2002 in Japan.

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[TITLE OF THE INVENTION] ENDLESS BELT DRIVING APPARATUS AND IMAGE FORMING APPARATUS

[ABSTRACT]

[PROBLEM]

An endless belt driving apparatus is provided. Even if a rotating body such as a photo-sensitive drum has an eccentricity, it stably operates integrally with an endless belt such as a conveyer belt, a transfer belt, or the like without slippage therewith or vibrations.

[SOLUTION]

A pair of rollers 62 are disposed in close proximity to a driving roller 3 and a photo-sensitive drum 5 and in contact with a conveyer belt 1. An eccentricity of the roller pairs 62 in close proximity to the driving roller 3 is made smaller so that fluctuations in the speed of the conveyer belt 1 are reduced when the driving roller 3 is controlled to rotate at a constant angular speed.

[TITLE OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] IMAGE FORMING APPARATUS

[CLAIMS]

[Claim 1]

An endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving said endless belt, and at least one rotating body directly or indirectly engaged in pressure contact with said endless belt for rotation associated with a movement of said endless belt and disposed side by side in a belt moving direction, said endless belt driving apparatus characterized by setting an allowable eccentricity of a driving roller forming part of said belt driving means to be small in a range not to affect fluctuations in belt speed, providing said rotating body with a roller in close proximity to said driving roller and in contact with said endless belt, and setting an allowable eccentricity of said roller to be small in a range not to affect fluctuation in the belt speed.

[Claim 2]

An endless belt driving apparatus according to claim 1, characterized by comprising an eccentricity adjusting mechanism for said driving roller and/or said roller in close proximity to said driving roller.

[Claim 3]

An endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving said endless belt, and at least one rotating body directly or indirectly engaged in pressure contact with said endless belt for rotation associated with a movement of said endless belt and disposed side by side in a belt moving direction, said endless belt driving apparatus characterized

by setting an allowable eccentricity of a driving roller forming part of said belt driving means to be small in a range not to affect fluctuations in belt speed, and providing said rotating body with a fixed guide body in close proximity to said driving roller and in contact with said endless belt.

[Claim 4]

An endless belt driving apparatus according to any of claims 1 to 3, characterized in that said driving roller is integrally formed with a driving shaft of said driving roller.

[Claim 5]

An endless belt driving apparatus according to any of claims 1 to 4, characterized in that a dynamic balance is integrally taken for a motor rotating section forming part of said belt driving means and said driving roller.

[Claim 6]

An endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving said endless belt,a driven roller disposed at the other end of said endless belt opposite to said belt driving means, and a plurality of rotating bodies directly or indirectly engaged in pressure contact with said endless belt for rotation associated with a movement of said endless belt and disposed side by side in a belt moving direction, said endless belt driving apparatus characterized by comprising a tension roller disposed at least one location between said rotating bodies, or between said belt movement driving means and said rotating body, or between said driven roller and said rotating body.

[Claim 7]

An endless belt driving apparatus comprising belt driving means

disposed at an end of an endless belt for moving said endless belt, and at least one rotating body directly or indirectly engaged in pressure contact with said endless belt for rotation associated with a movement of said endless belt and disposed side by side in a belt moving direction, said endless belt driving apparatus characterized by comprising a tension rollers disposed on both sides of a position of said endless belt at which said endless belt comes into contact with said rotating body.

[Claim 8]

An endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving said endless belt, and at least one photo-sensitive drum directly or indirectly engaged in pressure contact with said endless belt for rotation associated with a movement of said endless belt and disposed side by side in a belt moving direction, said endless belt driving apparatus characterized by directly driving a driving roller forming part of said belt driving means or said photo-sensitive drum with an outer rotor type coreless motor.

[Claim 9]

An endless belt driving apparatus according to claim 8, characterized by setting torque ripple generated by said outer rotor type coreless motor to a spatial frequency close to a maximum value of an allowable lower torque ripple spatial frequency range which does not affect an image quality.

[Claim 10]

An endless belt driving apparatus according to claim 8 or 9, characterized by using an outer rotor of said outer rotor type coreless motor in common with said driving roller.

[Claim 11]

An endless belt driving apparatus according to claim 8 or 9, characterized by integrally forming an outer rotor of said outer rotor type coreless motor with said driving roller.

[Claim 12]

An endless belt driving apparatus according to claim 8 or 9, characterized by driving said outer rotor type coreless motor such that timings at which currents are applied to coils of respective phases do not substantially overlap with one another when the current applied to the coil of each phase and a magnetic flux density of a magnetic field in a gap are substantially constant.

[Claim 13]

An endless belt driving apparatus according to any of claims 8 to 12, characterized by providing an encoder plate on an outer rotor of said outer rotor coreless motor, and providing said encoder plate with at least one mark of a control timing detecting mark for detecting a signal such as rotation control, or a phase switching signal detecting mark for detecting a phase switching signal for a current applied to a coil of each phase of said outer rotor type coreless motor.

[Claim 14]

An endless belt driving apparatus according to claim 13, characterized in that said phase switching signal detecting mark is additionally used as a mark for detecting a start signal which is output once per rotation.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD PERTINENT TO THE INVENTION]

The present invention relates to an endless belt driving apparatus which comprises a belt driving means for moving an endless belt, a rotating body arranged in parallel with the belt driving means in a belt moving direction for rotation associated with movements of the endless belt, and the like, as well as to an image forming apparatus such as a color laser printer, a copier or the like, including a tandem type, which comprises a belt driving means for moving an endless intermediate transfer belt or a sheet feeding belt, photo-sensitive drums arranged in parallel with the belt driving means in a belt moving direction for rotation associated with movements of the endless belt, and the like.

[0002]

[Prior Art]

In recent years, color copies have been increasingly needed. While an ink jet method is predominant as a printing unit in low speed printing, the electrophotography has become more pervasive in middle and high speed printing. There is a tandem type color copier which is particularly suitable for higher speeds.

[0003]

As disclosed in Laid-open Japanese Patent Application No. 10-246995 or No. 63-81373, the tandem type color copier has four photo-sensitive drums, each comprising an optical scanning unit, arranged on a conveyer belt in a paper sheet (recording sheet) feeding direction, such that the photo-sensitive drums are exposed to light beams emitted from the respective optical scanning units for scanning (an operation referred to as main scanning). This operation results in the formation of an electrostatic latent image on each of the

photo-sensitive drums. Each of the photo-sensitive drums is supplied with a toner of different color (cyan, magenta, yellow, black) from each developing unit, such that the electrostatic latent images are developed by the toners. Then, a paper sheet is fed to each of the photo-sensitive drums by the conveyer belt. In the middle of the feeding, the toner images on the respective photo-sensitive drums are sequentially transferred on the same scanning line by a transfer charger such that they match with each other. Subsequently, the resulting image id fixed, and the paper sheet is discharged onto a sheet discharge tray.

[0004]

In the foregoing manner, the tandem type color copier can parallelly draw four images on four photo-sensitive drums, and form images in four colors by passing a paper sheet below the respective photo-sensitive drums only once, so that this is an image forming method suitable for a high speed color copy.

[0005]

In a method employed by the tandem type color copier described, for example, in Laid-open Japanese Patent Application No. 10-246995, the conveying speed of the conveyer belt is matched with a peripheral speed of the peripheral surface of each photo-sensitive drum to scan the respective photo-sensitive drums at a constant timing, and color shifts are prevented by bringing each photo-sensitive drum into pressure contact with the conveyer belt using a pressure roller, and driving the conveyer belt to drive the respective photo-sensitive drums.

[0006]

In the method using the pressure roller, when the rotating shaft

of a photo-sensitive drum is free from eccentricity, the photo-sensitive drum has a constant rotational angular speed with the conveyer belt which is driven at a constant speed. However, if the shaft is eccentric, the rotational angular speed is not constant, as will be later described. Therefore, the method using the pressure roller will suffer from color shifts or image distortions on an image formed on a paper sheet unless consideration is made not only on the eccentricity but also even on fluctuations in the rotational angular speeds of the photo-sensitive drums.

[0007]

When higher resolutions (1200 dpi or more) are increasingly demanded in the future, it is difficult to realize a machining accuracy for the diameters of photosensitive drums, which support the higher resolutions, at a low cost. The eccentricity of a photo-sensitive drum, if any, would cause variations in the rotational angular speed thereof in the method using the pressure roller, so that required higher resolutions could not be readily supported with the prior art techniques.

[0008]

Further, in the prior art, the generation of exposure image data is adjusted by detecting the eccentricity of the photo-sensitive drums such that latent images on the photo-sensitive drums in the sub-scanning direction are at equal pitches. However, in this method, the eccentricity of the photo-sensitive drums during a transfer gives rise to a problem of variations in density on a transferred image.

[0009]

The inventors have previously made investigations in view of the problem mentioned above and has made an invention. However, for

problems associated with a driving mechanism including a driving roller mechanism for driving a belt, a belt mechanism, and a rotating motor for driving a driving roller, investigations have been made on regions without problems, so that these problems must be solved if a higher accuracy is required. In this way, the requirements for a higher accuracy makes variations in speed of the conveyer belt due to the driving roller non-negligible.

[0010]

Also, if a photo-sensitive drum has an eccentricity, the conveyer belt will be urged in a direction perpendicular to a belt running direction and released from the urging during one rotation of the photo-sensitive drum. While this phenomenon can be acceptable if the eccentricity is small, larger eccentricity would cause problems of a sagged conveyer belt and resulting slippage between the conveyer belt and the photo-sensitive drums if the respective photo-sensitive drums differ in the phase of the eccentricity from one another.

[0011]

Also, for driving a motor for driving a driving roller through a gear or a power transmission belt, there are problems of variations in the transmission speed due to eccentricity of gears or rollers (or pulleys) which hold the power transmission belt, vibrations caused by gears in mesh, and degraded transmission rigidity in the belt and the like. Further, there is a problem of variations in torque produced by torque ripple of a driving motor or cogging which are transmitted to a driving roller with an increase by a deceleration ratio provided by the gear or roller.

[0012]

In Laid-open Japanese Patent Application No. 10-63059, a

transmission mechanism composed of gears is used to decelerate the rotational speed of a motor, and a large fly wheel is attached to a rotating shaft of a photo-sensitive drum, which is to be controlled, to prevent vibrations which may occur in a transmission system and the like. In this configuration, in spite of the ability to reduce vibrations in a high frequency range caused by gears and the like, problematic difficulties are encountered in the prevention of variations in speed due to the eccentricity of a gear in the transmission system in the driving system, and in the performance of accurate control due to lower rigidity of the driving system.

[0013]

Laid-open Japanese Patent application No. 6-271130 describes prior art examples and embodiments of an invention related to a so-called direct driving method for solving the aforementioned problems, wherein a driving roller is integrated with a motor while removing a transmission mechanism comprised of gears and the like. In the former, a driving roller is connected to a motor through a driving shaft, while in the latter, a motor is coextensive to the overall area of the driving roller (corresponding to the width of a belt), such that the outer periphery of the motor is rotated in an outer rotor configuration. Here, pulse motors are used for the purpose. Also, the former suffers from low rigidity of the driving shaft and therefore is highly susceptible to external vibrations because it cannot increase the gain of a control system, in consideration of vibrations due to the distorted shaft. In the latter, since the motor is disposed in the driving roller, heat transferred to the belt causes a degraded quality of image. Also, since the motor is disposed in the long driving roller, difficulties in the

manufacturing results in a higher cost. Further, since the pulse motor is used, vibrations caused by the motor itself contribute to a degraded quality of image.

[0014]

The inventors have proposed the following control method and a control apparatus which can meet a required high resolution and is particularly effective in a tandem type image forming apparatus by virtue of the abilities to prevent distortions, color shifts, variations in density of images in the sub-scanning direction of the image even if photo-sensitive drums are machined with a low accuracy.

[0015]

Specifically, the controller is associated with an image forming apparatus which comprises means for scanning the peripheral surface of a photo-sensitive drum, line by line, in a direction perpendicular to a sheet feeding direction to write image data, and for transferring an image formed on the peripheral surface of the photo-sensitive drum onto a paper sheet, wherein the image forming apparatus includes recording sheet conveying means (conveyer belt) for conveying a paper sheet in pressure contact with the photo-sensitive drum. The photo-sensitive drum and conveyer belt can move without integral slippage of a contact face therebetween, so that the contact of the conveyer belt with the photo-sensitive drum is a maximum (peak) in a belt side direction in a circle cross-section of the photo-sensitive drum. Signal generating means (rotating angle detecting encoder) generates a signal corresponding to a sub-scanning pitch in synchronism with movements of a transfer belt (1/N of the sub-scanning pitch, where N is a natural number). Detecting means is provided on the conveyer belt for detecting an exposure start position.

Detecting means is provided on each of the photo-sensitive drums for detecting a reference position of its rotating angle (by generating a pulse per rotation for detection). A drive source for moving the conveyer belt, and signal generating means corresponding to the sub-scanning pitch are provided to control the movements or rotations. A drive source is provided in each of the photo-sensitive drums for correcting for transient fluctuations in load caused by a drum cleaner that may be disposed around each photo-sensitive drum, which is indispensable in a known electrostatic copy system, so that the photo-sensitive drum and conveyer belt stably move without integral slippage of the contact face therebetween.

[0016]

The photo-sensitive drum rotates at a constant rotating angular speed when the contact of the conveyer belt with the photo-sensitive drum is the maximum (peak) in the belt side direction in the circular cross-section of the photo-sensitive drum. However, variations in the diameters of the drums result in variations in the rotational speeds of the respective photo-sensitive drums. Therefore, the drive source for correcting a load for fluctuations is controlled to rotate such that it moves integrally with the conveyer belt in accordance with the diameter of each drum. Specifically, the drive source for correcting a load for the variations is controlled to rotate such that output pulses from the detecting means for detecting the reference position for the rotating angle of each of the photo-sensitive drums (outputting a pulse per rotation for detection) are generated at time intervals corresponding to a speed at which the drive source moves integrally with the conveyer belt.

[0017]

The following description will be made on the formation of an image in an image forming apparatus according to the invention of the inventors, i.e., a tandem type image forming apparatus which includes a conveyer belt for conveying a paper sheet in pressure contact with a photo-sensitive drum, and permitting the photo-sensitive drum and conveyer belt to move without integral slippage of a contact face therebetween. When a paper sheet passes between the photo-sensitive drum and the conveyer belt, they integrally move with the intervention of the paper sheet. This method can be applied not only to the belt-based system for conveying a paper sheet but also to a system which relies on an intermediate transfer belt.

[0018]

Fig. 23 illustrates an exemplary configuration of a conveyer unit in the image forming apparatus. In Fig. 23, an endless belt (conveyer belt) 1, which is the conveyer unit, is wound around a driven roller 2, a driving roller 3 and a tension roller 4. Four photo-sensitive drums (cyan (C), magenta (M), yellow (Y), black (BK)) 5 are disposed opposite to respective transfer corona chargers 6 across the conveyer belt 1. The tension roller 4 is configured as illustrated in Fig. 24, wherein a spring 7 applies an urging force to the movable conveyer belt 1 through a lever 8, so that the conveyer belt 1 is prevented by this spring pressure from sagging, and that the conveyer belt 1 is kept in pressure contact with the photo-sensitive drum 5 on its tangential line.

[0019]

This exemplary configuration is contemplated on the assumption that there is no problem in the mechanism of the driving roller 3 for driving the conveyer belt 1, the belt mechanism, and a driving

mechanism including a rotating motor for driving the driving roller 3. For helping the pressure contact of the conveyer belt 1 and photo-sensitive drum 1 which form a sheet feeding path, pressure rollers 9 are disposed between the respective photo-sensitive drums 5. The pressure rollers 9 are rotatably supported and resiliently urged to the endless belt 1. Thus, as the driving roller 3 is rotated at a constant speed by a driving motor, not shown, the conveyer belt 1 moves at a constant speed to convey a paper sheet on the conveyer belt 1 at a constant speed, and the photo-sensitive drums 5 are driven by the conveyer belt 1 to rotate.

[0020]

Here, an original image reader, an optical scanning unit, a sheet feeder unit including a sheet feed cassette, a fixer unit, and a paper discharge unit, required for a known color copier or color printer, as well as cleaners, chargers, developing units, and the like disposed around the photo-sensitive drums in an electrostatic electrophotography/image forming process unit, other than the photo-sensitive drums, are omitted in the figure.

[0021]

The characteristics of this exemplary configuration are on the premise that even if the photosensitive drums 5 have eccentricity, the contacts of the conveyer belt 1 with the photo-sensitive drums 5 are substantially at a maximum (peak) in the belt side direction in the circular cross-sections of the respective photo-sensitive drums.

[0022]

Next, description will be made in a specific manner on the relationship between the moving speed of the conveyer belt and the

rotating angular speed of the photo-sensitive drums, which constitutes the basis of the foregoing exemplary configuration, and on a method of correcting color shifts and image distortions based on the result in the formation of an image in the presence of eccentricity of the photo-sensitive drums, variations in the diameter, and variations in the positions of attachment.

· Relationship between Rotating Angular Speed of Photo-Sensitive Drums and Moving Speed of Belt

The relationship between each of the photo-sensitive drums 5 and the conveyer belt 1 in Fig. 23 can be modeled as illustrated in Fig. 25. In Fig. 25, when ε represents the amount of eccentricity, and θ represents the angle of an eccentric position to the x-axis, a moving speed of a contact T of the photosensitive belt 5 and the endless belt 1 is expressed by (Eq. 1) in coordinate representation.

[0023]

[Eq. 1]

$$(\varepsilon\sin\theta\cdot\omega,\ \varepsilon\cos\theta\cdot\omega),\ \omega=d\theta/dt$$

Thus, a speed Vs in a direction S rotating about the center O of rotation of the drum is found from (Eq. 2):

[0024]

[Eq. 2]

$$Vs = V\cos\alpha - \varepsilon\sin\theta\cdot\omega\cdot\cos\alpha + \varepsilon\cos\theta\cdot\omega\cdot\sin\alpha$$

where V is a vector moving speed, and α is the angle formed by a line perpendicular to a line r connecting the contact T from the center O of rotation of the drum at the position of the contact T to the belt. Therefore,

[0025]

[Eq. 3]

$$\omega = Vs/r = (V\cos\alpha - \varepsilon\sin\theta\cdot\omega\cdot\cos\alpha + \varepsilon\cos\theta\cdot\omega\cdot\sin\alpha)/r$$

From the cosine law:

[0026]

[Eq. 4]

$$r^2 = R^2 + \varepsilon^2 - 2R\varepsilon\sin(\pi/2-\theta) = R^2 + \varepsilon^2 - 2R\varepsilon\sin\theta$$

where R is the radius of the drum. Here, from the sine law:

[0027]

[Eq. 5]

$$\varepsilon/\sin\alpha = r/\sin(\pi/2-\theta) = r/\cos\theta$$

[0028]

[Eq. 6]

$$\sin\alpha = \varepsilon\cos\theta/r,\ \cos\alpha = (R-\varepsilon\sin\theta)/r$$

Substituting (Eq.4) and (Eq. 5) into (Eq. 3):

[0029]

[Eq. 7]

$$\omega = (VR - (V+\omega R) - \varepsilon\sin\theta + \omega\,\varepsilon 2\}/(R^2 + \varepsilon^2 - 2R\varepsilon\sin\theta)\ (\varepsilon\sin\theta - R)\ (V-R\omega) = 0$$

where $\varepsilon\sin\theta$ -0Ris established, so that the relationship of V=R ω is established.

[0030]

In other words, even if the photo-sensitive drum 5 has an eccentricity, the rotating angular speed of the drum is constant as the constant belt moving speed V without slippage.

[0031]

Therefore, even without providing each photo-sensitive drum 5 with a rotating angle detecting encoder which is capable of detecting an absolute angular position, a rotating angular position of the photo-sensitive drum can be predicted if it is provided with a detector

for detecting a movement or an absolute position of the conveyer belt 1 (for example, a linear encoder for detecting marks attached at regular intervals along an end of the conveyer belt 1 which is not passed by paper, and a mark on the belt indicative of a reference position to recognize an absolute position), and a detector which is capable of detecting a rotating angle reference position for the rotation of the photo-sensitive drum (generating one pulse output per rotation for the detection). Specifically, the photo-sensitive drum 5 is rotated, and an linear encoder measures one period of the rotation of the drum, detected by the rotating angel/reference position detector. From the result of the measurement, the rotating angle of the photo-sensitive drum per pulse output from the linear encoder can be found. While the foregoing description has been made with an example which uses a linear encoder, a rotating angle encoder can be used for a system in which a driving roller has small eccentricity with respect to a required image quality, and a rotating angle encoder is not affected by eccentricity of the encoder itself.

[0032]

Then, the slippage can be eliminated by a constant rotating angle speed control with the rotating angular speed of each photo-sensitive drum 5 commensurate with the diameter of the drum.

[0033]

However, in the prior art configuration as illustrated in Fig. 26, where even if the photo-sensitive drum 5 has an eccentricity, the contact T of the conveying belt 1 with the photo-sensitive drum 5 is not at the maximum (peak) on the belt side in the circular cross-section of the photo-sensitive drum 5, even a constant speed of the conveyer belt 1 does not result in a constant rotational speed

of the photo-sensitive drum 5, so that the foregoing cannot be applied thereto.

[0034]

Specifically, in the configuration illustrated in Fig. 26, the photo-sensitive drums 5 are in pressure contact with the conveyer belt 1 between the photo-sensitive drums 5 and the pressure rollers 9 by an urging spring force applied to the pressure rollers 9 by a spring urging structure similar to that in Fig. 24, thereby transmitting a driving force from the conveyer belt 1 to the photo-sensitive drums 5. Since the contact of the conveyer belt 1 with the photo-sensitive drum 5 is below the rotating shaft of the photo-sensitive drum 5 (center O of rotation), i.e., near the y-axis, the rotating angular speed of the photo-sensitive drum 5 fluctuates due to the eccentricity.

· Angle from Exposure Position to Transfer Position

In an explanatory diagram of Fig. 27, a transfer position is determined by a broken-line triangle OGE ("transfer triangle" of interest associated with the transfer) determined at the instance of exposure. Specifically, an image exposed at a position E (herein referred to as the eccentric position) at which the center of gravity (center in the circular cross-section of the photo-sensitive drum) G of the photo-sensitive drum 5 is at a rotating angle θ (angle GOx), is transferred at a position (x=-s) T deviated from an ideal transfer position (x=0) after rotation by a rotating angle Θt.

[0035]

Then, the rotating angle Θt from the exposure to the transfer is in a relationship represented by (Eq. 8):

[0036]

[Eq. 8]

$$\Theta t = \pi - \beta$$

where β is the angle GEO. Further, since $\sin\beta$ and Θt satisfy

[0037]

[Eq. 9]

$$\sin\beta = (\varepsilon/R)\cos\theta$$

[0038]

[Eq. 10]

$$\Theta t = \pi - \sin^{-1}\{(\varepsilon/R)\cos\theta\},$$

s indicative of the transfer position is represented by:

[Eq. 11]

$$s = \varepsilon\cos(\theta-\beta) = \varepsilon\cos\theta(\varepsilon/R)[\{(R/\varepsilon)^2-\cos^2\theta\}^{1/2} + \sin\theta]$$

[0040]

From the foregoing result, in a configuration in which the contact T of the photo-sensitive drum 5 with the conveyer belt 1 moves without integrally slipping, and is at the maximum (peak) in the belt side direction in the circular cross-section of the photo-sensitive drum 5, the rotating angle Θt from stable exposure to transfer can be found from (Eq. 10), provided that the angle θ of eccentricity and the amount ε of eccentricity at the time of exposure are known, to generate image data with which an image can be corrected for distortions and color shifts.

· Method of Generating Image Data

This correcting method is a correcting method intended to adjust a timing at which a main scanning image is generated such that data is transferred onto a conveyer belt at an ideal position at all times. With the radius R_0 of an ideal photo-sensitive drum free from eccentricity, a transfer is made after the conveyer belt has moved

by πR_0 after exposure. However, if eccentricity causes variations in the drum diameter, a transfer is made after a rotating angle Θt of the drum subsequent to the exposure, causing the transfer position to shift by -s from the transfer position T with the ideal photo-sensitive drum. A transferred image on the conveyer belt moves at a speed of V after the transfer. Exposure data is transferred with a shift of -s from the ideal transfer position T after a time $\Theta t/\omega = \tau$. In other words, it is transferred after the transfer belt has moved by the distance of $V\tau$ after the exposure.

[0041]

(Eq. 12) is established:

[0042]

[Eq. 12]

$$V = R_0\omega_0$$

where R_0 is the radius of the ideal drum, and ω_0 is the rotating angle speed of the drum in this event.

Thus, with the ideal drum, the exposure data should be transferred in a time $\pi/\omega_0 = \tau_0$.

[0043]

Consequently, on the endless belt, an image which should be at a belt moving distance $x=V\tau_0$ after the exposure is formed at $x=V\tau$. As such, an ideal image can be produced if image data corresponding to $x=V\tau$ is generated on the exposure side. Since reference data for generating an image is created on the basis of an ideal photo-sensitive drum, such a concept is required. Specifically, data before $d=V(\tau_0-\tau)$ should be generate. In other words,

[0044]

[Eq. 13]

$$V = R\omega = R_0\omega_0$$

[0045]

[Eq. 14]

$$\Theta t = \pi - \sin^{-1}\{\varepsilon/R)\cos\theta)$$

[0046]

[Eq. 15]

$$d = V(\pi/\omega_0 - \Theta t/\omega) = R[\pi\omega/\omega_0 - \pi + \sin^{-1}\{(\varepsilon/R)\cos\theta\}]$$

[0047]

[Eq. 16]

$$d = \pi(R_0 - R) + R\sin^{-1}\{(\varepsilon/R)\cos\theta\}]$$

so that data should be delayed by d in accordance with (Eq. 16) (data is sent forward (advanced) depending on the angle θ).

[0048]

In conclusion, data should be generated with a shift of $d=\pi(R_0-R)$ when there is no eccentricity. In this event, since the peripheral speed of the photo-sensitive drum is at a constant speed V, the sub-scanning pitch for a transfer image is constant (no variations in density), as can be readily understood. As illustrated in Fig. 27, when the photo-sensitive drum 5 has an eccentricity, the peripheral speed of the photo-sensitive drum 5 at a transfer position (contact position) T is determined by the distance e from the center O of the rotation of the drum, and even if this peripheral speed is not equal to the speed V, the conveyer belt 1 and photo-sensitive drum 5 cooperate with each other at all times without slippage at the transfer position, permitting the conveyer belt 1 to move at the constant speed V. In other words, since the transfer position T, at which the photo-sensitive drum 5 comes into contact with the conveyer belt 1, is moving, this movement absorbs the difference in speed

between the photo-sensitive drum 5 and the conveyer belt 1.

[0049]

Here, when the exposure position is defined in opposition to the conveyer belt 1, an image exposed at a distance e from the center O of rotation of the photo-sensitive drum, for example, is transferred at a position distanced by e, so that the peripheral speed is equal at the exposure position and at the transfer position. In other words, a latent image at a line density exposed at the exposure position is transferred at the transfer position when the peripheral speed is the same. Since the transfer position is moving, the line density of the latent image is the same as the line density when a latent image exposed at the peripheral speed V, when there is no eccentricity, is formed from the transfer belt 1. Thus, the line density of the transferred image is constant. Stated another way, the exposure at a position corresponding to the peripheral speed of the photo-sensitive drum at the transfer position is equivalent to exposure without eccentricity.

[0050]

In the state illustrated in Fig. 27, the line density of the latent image is coarse because the peripheral speed is high at the exposure position E. This latent image at a low line density is scanned on the conveyer belt 1 at a speed higher than the speed V of the transfer belt 1 at the transfer position T, so that the transfer image is corrected toward a higher line density.

[0051]

Thus, even if the photo-sensitive drum 5 has an eccentricity, the image is free from variations in density when the exposure position is defined in opposition to the conveyer belt 1.

· Method of detecting Eccentricity ε and Radius R of Photo-Sensitive Drum

(1) Self Measurement Method

The radius of a photo-sensitive drum can be found by moving an endless transfer belt by a length $L=2\pi R_0$ corresponding to the peripheral length of an ideal drum, and detecting a rotating angle θi of a rotating angle detecting encoder directly coupled to the photo-sensitive drum at this time. In other words, the radius of the photo-sensitive drum can be calculated by:

[0052]

[Eq. 17]

$$R = L/\theta i$$

[0053]

Alternatively, if no rotation encoder is available so that the reference position for the rotating angle can merely be detected, a moving distance Lb of the belt may be found when the photo-sensitive drum rotates once. In other words, the radius may be calculated by:

[0054]

[Eq. 18]

$$R = Lb/(2\pi)$$

[0055]

The position of eccentricity ε can be detected by detecting a displacement of the peripheral surface based on the eccentricity of the photo-sensitive drum, by way of example. A detector may be comprised, for example, of a light emitting device for emitting a light beam to a displacement detecting position on the peripheral surface of the photo-sensitive drum; a light receiving device (for example, a bisect photodiode device) for receiving the light beam

reflected by the photo-sensitive drum; an optical system which causes a change in light sensed on the light receiving device in response to fluctuations in the peripheral surface of the photo-sensitive drum due to the eccentricity (for example, an optical system which uses a focus error detecting method or the like as implemented, for example, in an optical disk apparatus); and the like. By doing so, an optical current in accordance with a change in the distance between the detector and the detected position flows into the light receiving device. Thus, the position of eccentricity can be detected by detecting the optical current. For example, the position of eccentricity (θ,ε) from the x-axis can be found by detecting a zero-cross point and a peak point for a change in an output signal when the photo-sensitive drum is rotated with the detector disposed, for example, on the plus side on the x-axis in Fig. 27, and calculating the angle θ from the amplitude ε at the peak point and the angle θ from the x-axis.

[0056]

This method only requires to detect where the position of eccentricity (θ,ε) is in the rotating angle of the photo-sensitive drum (of course, information on the amplitude ε of the eccentricity is necessary). In other words, even when another means is used to detect the rotating angle of the photo-sensitive drum, it is only required to find where a detected position of eccentricity is in the rotating angle of the photo-sensitive drum, and how the amplitude ε is about.

[0057]

(2) Method of Measuring in Factory

The radius R and eccentricity ε of the photo-sensitive drum as

well as information on angle θ_0 from a reference position (home position) of a rotation encoder or a rotating angle reference position detector associated with the rotation of the photo-sensitive drum having the eccentricity ε is measured in a factory, and the information is recorded in a memory (a flash memory or the like) mounted in a tandem type image forming apparatus for use in deriving the aforementioned correction value d. In this way, the measurements can be implemented. For replacing the photo-sensitive drum, a service person or a user may input data described on a photo-sensitive drum for replacement or accompanying data into the memory for recording.

· Description on Sequence of Operations

Fig. 28 is an explanatory diagram illustrating a plan view of an exemplary configuration for describing a control process in an image forming apparatus which basically has a similar conveyer unit to that of Fig. 23 in structure, wherein four photo-sensitive drums (cyan (C), magenta (M), yellow (Y), black (BK)) are disposed on an endless conveyer belt 1. Each of the photo-sensitive drums 5 is provided with a detector, not shown, for detecting a reference position for a rotating angle, and a detector for detecting a displacement of the plane of the photo-sensitive drum 5 to detect the position of eccentricity.

[0058]

In Fig. 28, first, when the power is turned on, the conveyer belt 1 is driven without feeding a paper sheet. Since the conveyer belt 1 and photo-sensitive drums 5 are arranged to integrally move with each other without slippage, the photo-sensitive drums 5 rotate. Then, one rotation of each photo-sensitive drum 5 is detected by the output of the detector for detecting the reference position for the

rotating angle, and the number of output pulses from a belt movement detecting linear encoder at this time is detected to measure the diameter of the photo-sensitive drum 5 (the phase of pulse interval is also measured to improve the accuracy in some cases). Also, the output of the eccentricity position detector, not shown, is detected to measure the position of eccentricity with the output of the detector for detecting the reference position for the rotating angle over one rotation of the photo-sensitive drum 5, and the output of the belt movement detecting linear encoder. Since the number of output pulses from the belt movement detecting linear encoder corresponding to one rotation of the photo-sensitive drum 5 is known, the rotating angle can be calculated. The amplitude of eccentricity can be detected by detecting an AC amplitude of the waveform of the output from the eccentricity position detector.

[0059]

The foregoing information is detected for each of the photo-sensitive drums 5 which are forced to perform similar operations. Then, the correction value in (Eq. 16) $d = \pi(R_O - R) + R\sin^{-1}\{(\varepsilon/R)\cos\theta\}]$ is calculated for each photo-sensitive drum 5 over one full rotation ($\theta = 0 - 2\pi$) with the respective detected data, and stored in a memory within a controller, not shown, as a reference table.

[0060]

Next, a reference mark 13 is detected by a leading end position detector 12 disposed at one end of the conveyer belt 1, and main scanning data is recorded on each of the photo-sensitive drums 5 for transferring a test mark onto the reference mark 13 on the assumption that each photo-sensitive drum 5 is at an ideal position and in an ideal shape.

[0061]

Here, a consideration is made for the case where the timing phase for the main scanning of a polygon mirror, which forms part of an optical system for exposing the photo-sensitive drums 5, does not match with the timing phase for the sub-scanning which is synchronized with the movement of the conveyer belt 1. The timing at which the main scanning is started is determined on the basis of a pulse signal generated by a detector 11 for the belt movement detecting linear encoder in response to a detection of the timing mark 14 for the belt movement detecting linear encoder on the conveyer belt 1, but it does not always match with the timing for the main scanning of the polygon mirror. Therefore, if the timing for the main scanning of the polygon mirror has not come when an ideal test mark recording and generating timing comes up, the test mark is recorded at the timing for the main scanning of a polygon motor for driving a polygon mirror which comes later.

[0062]

Then, as illustrated in Fig. 29, after detecting a difference between the test mark 15 recorded on the conveyer belt 1 and the reference mark 13, it is possible to correct the photo-sensitive drum 5 for a mounting error by correcting for d (correction value) caused by the eccentricity ε and variations in the radius R, and for the delay produced here. In this way, the correction value d required for the position at which the photo-sensitive drum 5 is mounted, the eccentricity ε of the photo-sensitive drum 5, and variations in the radius R can be found, so that an image free from color shifts or distortions can be formed by generating image data using data on the correction value d.

[0063]

In Fig. 28. 16 designates a sheet leading end position passage detector; 17, a reference position error detector; and 18, a sheet passage region.

[0064]

A basic item which can realize the foregoing is that the photo-sensitive drum and conveyer belt move in synchronism without slippage. Since the contact of the conveyer belt with the photo-sensitive drum is at the maximum (peak) in the belt side direction in the circular cross-section of the photo-sensitive drum, this is quite effective in correcting color shift and image distortions in images. However, the exemplary configuration illustrated in Fig. 23 is more susceptible to slippage as compared with the exemplary configuration of the pressure roller method illustrated in Fig. 26.

[0065]

To solve the above, it is contemplated that each of the photo-sensitive drums is provided with a drive source for correcting fluctuations in load, such that fluctuations in load caused by a cleaner or the like disposed around each photo-sensitive drum is prevented from causing the slippage on the plane on which the conveyer belt is in contact with the photo-sensitive drum. In other words, fluctuations in load occurring in each of the photo-sensitive drums are prevented from transmitting to the others through the conveyer belt within the system. Description will be made with reference to an exemplary configuration illustrated in Fig. 30.

[0066]

In Fig. 30, members corresponding to the members described in

Figs. 23, 29 are designated the same reference numerals. The speed control for the overall system is conducted by use of an encoder 21 directly coupled to a shaft 3a of a roller 3 for driving the conveyer belt 1 for detecting a rotating angle, and a motor 22 for overall driving. This exemplary configuration is investigated in a region where the eccentricity of the driving roller 3 does not yet affect fluctuations in the speed of the belt. Also, a load fluctuation correcting motor 23 provided for each of the photo-sensitive drums 5 is configured to transmit a driving force through a small roller on the outer periphery outside of the image forming section in the photo-sensitive drum in order to reduce the size, as will be later described. Each of the photo-sensitive drums 5 is also provided with a rotating angle reference position detector 24 for detecting the reference position for the rotating angle to generate one pulse per rotation. A reference mark, not shown, is attached on the conveyer belt 1, so that this mark is detected by the leading end position detector 25.

[0067]

Fig. 31 is a diagram illustrating the configuration around the motor for correcting fluctuations in load. A roller 28 is mounted on the output shaft 23a of the load fluctuation correcting motor 23. The roller 28 receives a spring urging force to come into pressure contact with the photo-sensitive drum 5. The roller 28 is applied with the urging force of a spring 27 through a lever 26.

[0068]

The detection data from the respective detecting means illustrated in Fig. 30 are used for the control as previously described as well as for sensing a fault when slippage occurs between the

conveyer belt 1 and the photo-sensitive drums 5. Specifically, whether the driving is normal or faulty is sensed by determining whether or not the period of the output of the detector 24 sensed by rotating the photo-sensitive drum 5 once, and the rotating angle of the encoder 21 rotated by the overall driving motor 22 deviate from a defined relationship.

[0069]

Next, description will be made on the control using the overall driving motor 22 and encoder 21 in the exemplary configuration illustrated in Fig. 30.

[0070]

Fig. 32 is an explanatory diagram of the circuit configuration associated with a driving system for the driving roller. The rotational speed of the overall driving motor 22 ω_r is represented by V/Rr, where V is a target speed of the conveyer belt 1, and Rr is the radius of the driving roller 3. The output pulse frequency fr of the encoder 21 is represented by:

[0071]

[Eq. 19]

$$fr = Nr \cdot \omega_r / (2\pi) = Nr \cdot V / (2\pi Rr)$$

when the conveyer belt 1 is moving at a speed V, where Nr is the number of pulses per rotation of the encoder 21. A pulse (clock) fr equal to this frequency is applied to a reference pulse input of a control circuit illustrated in Fig. 32.

[0072]

This pulse signal is compared with the output of an encoder pulse detector 30 by a phase comparator 31, and the resulting error output is passed through a charge pump circuit 32 and a low pass filter (LPF)

33, and converted to a voltage (analog) signal which is input to a power amplifier 34. This is an uniform-speed control for a motor and the like based on a known PLL (Phase Locked Loop) method. Then, the output of the encoder pulse detector 30 is input to a frequency-to-voltage (f-V) converter 35 to produce a voltage signal proportional to the rotating angular speed. This signal is fed back to the input of the power amplifier 34 through a phase compensator 36, thereby improving the control characteristics in this speed control system. A feed-forward signal provides a feed-forward control to increase the accuracy of the control when the timing and amount of fluctuations in load around the conveyer belt 1 is previously known with certainty.

[0073]

Fig. 33 illustrates an exemplary configuration of the rotation control system for the load fluctuation correcting motor. Basically, this control system cancels fluctuations in load with a torque of the load fluctuation correcting motor 23 to minimize the fluctuation in load which are transmitted through the conveyer belt 1. The following description will be centered on the processing for controlling the rotation of the load fluctuation correcting motor.

[0074]

Since the photo-sensitive drums rotate integrally with the conveyer belt moving at a speed V, the photo-sensitive drums rotate at a rotating angular speed $\omega=V/R$. Therefore, no slippage will occur if each of the photo-sensitive drums can be controlled to rotate at the rotational speed $\omega=V/R$. With the diameter R_0 of an ideal photo-sensitive drum, the number of pulses N_0 output from the encoder, when the photo-sensitive drum rotate once, is represented by:

[0075]

[Eq. 20]

$N_0 = R_0 \cdot Nr/Rr$

If the mechanism is designed such that R_0/Rr is a natural number, a more accurate control is readily carried out. Then, the output of the encoder when the photo-sensitive drum is rotated once is measured in order to measure the radius R of the actual photo-sensitive drum. In this event, the number of pulses output from the encoder is represented by N+R, where N is the number of detected pulses, when the phase indicative of the interval between pulses is $2\pi P$ (where $0<P<1$). The radius R of the photo-sensitive drum in this event is represented by $R = Rr(N+R)/Nr$. Therefore, the photo-sensitive drum should be rotated at the rotating angular speed $\omega=V/R=V \cdot Nr/\{Rr(N=P)\}$ in order for the photo-sensitive drum to move integrally with the conveyer belt at the speed V. The rotating angular speed ω_0 of a photo-sensitive drum in an ideal shape is $\omega_0=V/R_0$.

[0076]

From the foregoing,

[0077]

[Eq. 21]

$\omega = \{N_0(N+P)\}\omega_0$

is established. In this event, the rotating angle reference position detector 24 associated with the photo-sensitive drum outputs pulses at a frequency fd:

[0078]

[Eq. 22]

$fd = \omega/(2\pi)$

The rotating angle reference position detector 24 associated with the photo-sensitive drum in the ideal shape outputs pulses at a

frequency fd_0:

[0079]

[Eq. 23]

$$fd_0 = \omega_0/(2\pi)$$

Then, the relationship between fr and fdo is found from:

[0080]

[Eq. 24]

$$fr = Nr \cdot V/(2\pi Rr) = (Nr \cdot R_0/Rr)fd_0$$

$fd_0=\{Rr/(Nr \cdot Ro)\}fr$ is established.

[0081]

A PLL control system is built using the foregoing relationship.

[0082]

Fig. 34 illustrates the configuration of a circuit for providing the clock frequency fd of a reference input for a load fluctuation correction rotation control system.

[0083]

In Fig. 34, the frequency fd_0 is first formed by a frequency synthesizer 40 on the basis f a reference pulse frequency which is compared with the pulses output from the encoder. This frequency fr is generated by an oscillator (not shown) which oscillates a frequency determined by (Eq. 19). In Fig. 34, k is a natural number which is determined in accordance with the accuracy with which the encoder can detect phase information. For example, when the phase detection resolution is 0.2x2π, k should be selected from proper numbers equal to or more than five. fdo is multiplied by $k \cdot N_0$ in a PLL system 41 composed of a phase detector, a charge pump, a loop filter, a VOC, and a $k \cdot N_0$ counter to be $k \cdot N_0 \cdot fd_0$ which is then divided in a k(N+P) counter 42 to derive fd. The k(N+P) counter 42 is a counter which

can set a count value. The count value is determined by the measured value mentioned above. In this event, a number rounded to a natural number is used for kP, as a matter of course. The circuit of Fig. 34 is provided separately in correspondence to each of the photo-sensitive drums. However, for simplifying the circuit for each photo-sensitive drum in Fig. 34, the circuit from the input fr to the output $k \cdot N_0$ can be used in common.

[0084]

The circuit illustrated in Fig. 33 comprises a PLL system 39 which has the reference input fd that is output by Fig. 34. The circuit of Fig. 33 is required for each of the photo-sensitive drums for driving the same. The reference input fd is compared with the output of the rotating angle reference position detector 24 in phase for the uniform-speed rotation control. From the foregoing, the speed is appropriately controlled in accordance with variations in the radius of the photo-sensitive drum in such a manner that the slippage is prevented.

[0085]

Then, when fluctuations in load around the photo-sensitive drums, or the timing and amount of fluctuations in load of the conveyer belt have been previously known with certainty, a controller outputs a feed-forward signal FF for individual feed-forward control in response to such fluctuations in order to increase the accuracy of the control.

[0086]

Also, for increasing the stability for the control, a signal proportional to the rotational speed of the photo-sensitive drum is detected from the load fluctuation correcting motor 23, and a speed

feedback system is added. Specifically, in this example, the PLL system controls for the pulse which is output once per rotation of the photo-sensitive drum, so that this speed feedback system is provided for correcting fluctuations which may occur between pulses.

[0087]

The controller generates reference speed data corresponding to (Eq. 21) which is input to a D-A converter 38, the output of which is compared with a counter-electromotive force generated in proportion to the speed of the load fluctuation correcting motor 23. Here, the counter-electromotive force of the motor is detected by subtracting the internal resistance r of the motor from the voltage across the terminals of the motor. Also, a power amplifier 37 is employed in this example because it can improve the characteristics of the control system. The phase compensator 36 is also provided for improving the characteristics of the control system. The control in this example is characterized in that the overall speed control is carried out by the overall driving motor 22, and individual fluctuations in load are corrected by the load fluctuation correcting motor 23.

[0088]

Another consideration which should be taken here is a requirement for a control intended to further reduce fluctuations in load caused by control errors in the control system for the load fluctuation correcting motor and transmitted to the overall driving control because of the slippage which is more likely to occur when there is a small frictional force between the photo-sensitive drums and the conveyer belt, or between the photo-sensitive drums and a paper sheet, or between the paper sheet and the conveyer belt.

[0089]

Since the error in the control system for the load fluctuation correcting motor acts as a load on the conveyer belt driving system as described above, the waveform of a current of the motor for driving the conveyer belt must be observed to determine whether or not a correction for the load fluctuation correcting motor is excessive, insufficient, or proper to correct the reference clock or the reference signal amplitude of the control system for the load fluctuation correcting motor. Though the inventors have studied this control method as well, description thereon is omitted here.

[0090]

[Problem to be Solved by the Invention]

In the image forming apparatus described in the prior art, the following problems implied in the driving roller mechanism for driving the belt, the belt mechanism, the driving mechanism including the rotating motor for driving the driving roller are solved such that the conveyer belt or the belt including the intermediate transfer belt can be accurately controlled to run at a uniform speed, thereby implementing an image apparatus such as a printer, a copier or the like with a high image quality.

[0091]

However, as a higher accuracy is required, fluctuations in the speed of the belt due to the eccentricity of the driving roller cannot be ignored. Also, if the belt or the photo-sensitive drum has an eccentricity, the belt is urged in the direction perpendicular to the belt running direction and released from the urging during one rotation of the photo-sensitive drum. Though a small eccentricity may be acceptable, a larger eccentricity will cause the belt to sag

if the respective photo-sensitive drums differ in the phase of eccentricity, resulting in slippage between the belt and the photo-sensitive drums.

[0092]

Also, when the motor for driving the driving roller is driven through a gear or a belt for transmitting a driving power, it is necessary to address problems to be solved, which include fluctuations in transmission speed due to the eccentricity of the gear or a roller for holding the belt, vibrations caused by engagement of gears, and a deterioration in transmission rigidity due to the belt and the like, as well as to address and solve problems to be solved, which include an increase in torque fluctuations caused by torque ripple or cogging of the motor in proportion to deceleration, a higher accuracy in the contact of the belt with the photo-sensitive drum at a peak position in the circular cross-section thereof, simplification of the apparatus, and a reduction in cost.

[0093]

It is an object of the present invention to further improve the prior art and to provide an endless belt driving apparatus suitable for use in an image forming apparatus such as a color laser printer, a copier and the like, including a tandem type, which stably operates, for example, a rotating body such as a photo-sensitive drum integrally with an endless belt such as a conveyer belt or a transfer belt without slippage or vibrations, and more particularly, to provide techniques for realizing an image forming apparatus which can stably operate the photo-sensitive drums at a constant rotating angular speed with few color shifts, image distortions, and variations in density, even if the photo-sensitive drums have eccentricities, as long as the

conveyer belt is running at a constant speed, and for reducing vibrations in a mechanism which drives the belt at a uniform speed if a driving roller for driving the belt is controlled to rotate at a uniform angular speed, and in a mechanism including a motor for driving the driving roller resulting from deteriorations in images. This technique for reducing vibrations can be applied as well to a mechanism for driving the photo-sensitive drums.

[0094]

[Means for Solving the Problems]

To achieve the above object, the invention set forth in claim 1 is an endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving the endless belt, and at least one rotating body directly or indirectly engaged in pressure contact with the endless belt for rotation associated with a movement of the endless belt and disposed side by side in a belt moving direction. The endless belt driving apparatus is characterized by setting an allowable eccentricity of a driving roller forming part of the belt driving means to be small in a range not to affect fluctuations in belt speed, providing the rotating body with a roller in close proximity to the driving roller and in contact with the endless belt, and setting an allowable eccentricity of the roller to be small in a range not to affect fluctuation in the belt speed. With this configuration, by regulating the allowable eccentricity in the driving roller and the roller in close proximity to the driving roller, the endless bent can be stably and accurately controlled to run at a uniform speed only if the driving roller is controlled to rotate at a uniform angular speed.

[0095]

The invention set forth in claim 2 is the endless belt driving apparatus according to claim 1, characterized by comprising an eccentricity adjusting mechanism for the driving roller and/or the roller in close proximity to the driving roller. With this configuration, the eccentricity of the driving roller and/or the roller in close proximity thereto can be readily limited within a target accuracy, thereby making it possible to stably and accurately control the endless belt to run at a uniform speed.

[0096]

The invention set forth in claim 3 is an endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving the endless belt, and at least one rotating body directly or indirectly engaged in pressure contact with the endless belt for rotation associated with a movement of the endless belt and disposed side by side in a belt moving direction. The endless belt driving apparatus is characterized by setting an allowable eccentricity of a driving roller forming part of the belt driving means to be small in a range not to affect fluctuations in belt speed, and providing the rotating body with a fixed guide body in close proximity to the driving roller and in contact with the endless belt. By regulating the allowable eccentricity in the driving roller, and regulating movements of the endless belt in a direction perpendicular to the belt moving direction (vertical direction) by the fixed guide body in close proximity to the driving roller, the endless bent can be stably and accurately control to run at a uniform speed only if the driving roller is controlled to rotate at a uniform angular speed.

[0097]

The invention set forth in claim 4 is the endless belt driving

apparatus according to any of claims 1 to 3, characterized in that the driving roller is integrally formed with a driving shaft of the driving roller. With this configuration, the eccentricity of the driving roller can be reduced, thereby making it possible to stably and accurately control the endless belt to run at a uniform speed.

[0098]

The invention set forth in claim 5 is the endless belt driving apparatus according to any of claims 1 to 4, characterized in that a dynamic balance is integrally taken for a motor rotating section forming part of the belt driving means and the driving roller. With this configuration, a highly accurate dynamic balance can be taken, thereby enabling a stable uniform angular speed control to stably control the endless belt to run at a uniform speed.

[0099]

The invention set forth in claim 6 is an endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving the endless belt,a driven roller disposed at the other end of the endless belt opposite to the belt driving means, and a plurality of rotating bodies directly or indirectly engaged in pressure contact with the endless belt for rotation associated with a movement of the endless belt and disposed side by side in a belt moving direction. The endless belt driving apparatus is characterized by comprising a tension roller disposed at least one location between the rotating bodies, or between the belt movement driving means and the rotating body, or between the driven roller and the rotating body. With this configuration, it is possible to prevent such a phenomenon as a sagged endless belt resulting from the eccentricity of the rotating body, to consequently prevent the

occurrence of slippage between the endless belt and the rotating body, and to enable stable integral motions of the rotating body with the endless belt.

[0100]

The invention set forth in claim 7 is an endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving the endless belt, and at least one rotating body directly or indirectly engaged in pressure contact with the endless belt for rotation associated with a movement of the endless belt and disposed side by side in a belt moving direction. The endless belt driving apparatus is characterized by comprising a tension rollers disposed on both sides of a position of the endless belt at which the endless belt comes in contact with the rotating body. With this configuration, the endless belt can more accurately come into contact with the rotating body at the peak position in the circular cross-section of the rotating body. As long as the endless belt runs at a uniform speed, an associative motion can be made if the rotating body is controlled to rotate at a uniform angular speed even with the eccentricity of the rotating body. In other words, the rotating body may be rotated at a uniform angular speed, which is easy to control, in order to force the associative motion.

[0101]

The invention set forth in claim 8 is an endless belt driving apparatus comprising belt driving means disposed at an end of an endless belt for moving the endless belt, and at least one photo-sensitive drum directly or indirectly engaged in pressure contact with the endless belt for rotation associated with a movement of the endless belt and disposed side by side in a belt moving direction.

The endless belt driving apparatus is characterized by directly driving a driving roller forming part of the belt driving means or the photo-sensitive drum with an outer rotor type coreless motor. With this configuration, the inertia moment of the rotor of the motor is increased to provide a fly wheel effect. Also, the employment of the coreless motor method eliminates the occurrence of vibrations due to cogging, fluctuations in transmission speed due to the gear or driving transmission belt of the driving means, vibration, and degraded transmission rigidity, thereby realizing an image forming apparatus which provides a high image quality.

[0102]

The invention set forth in claim 9 is the endless belt driving apparatus according to claim 8, characterized by setting torque ripple generated by the outer rotor type coreless motor to a spatial frequency close to a maximum value of an allowable lower torque ripple spatial frequency range which does not affect an image quality. With this configuration, there is no influence of a degraded image quality due to the torque ripple, and a high generated torque ripple spatial frequency is selected, so that it is possible to employ a configuration which can increase the motor torque, and the efficiency of the motor can be improved, thereby making it possible to realize an image forming apparatus which is small in size and provides a high image quality.

[0103]

The invention set forth in claim 10 is the endless belt driving apparatus according to claim 8 or 9, characterized by using an outer rotor of the outer rotor type coreless motor in common with the driving roller. With this configuration, degradation in twist rigidity, which occurs when a driving torque produced by the outer rotor type

coreless motor transmits to the driving roller through the coaxial shaft of the motor, is eliminated, so that higher rigidity can be realized, thereby making it possible to perform extremely stable high accurate control, make the configuration simple, and reduce the size and cost.

[0104]

The invention set forth in claim 11 is the endless belt driving apparatus according to claim 8 or 9, characterized by integrally forming an outer rotor of the outer rotor type coreless motor with the driving roller. With this configuration, higher rigidity can be realized, an adjustment for the dynamic balance is facilitated, an image forming apparatus which provides a high image quality can be provided, and a lower price can be expected by reducing the number of used bearings. In addition, the machining can be facilitated, and the size can be reduced.

[0105]

The invention set forth in claim 12 is the endless belt driving apparatus according to claim 8 or 9, characterized by driving the outer rotor type coreless motor such that timings at which currents are applied to coils of respective phases do not substantially overlap with one another when the current applied to the coil of each phase and a magnetic flux density of a magnetic field in a gap are substantially constant. With this configuration, it is possible to reduce fluctuations in torque caused by torque ripple produced from the motor, improve the motor efficiency as well, thereby realizing an image forming apparatus which provides lower power consumption and a high image quality.

[0106]

The invention set forth in claim 13 is the endless belt driving apparatus according to any of claims 8 to 12, characterized by providing an encoder plate on an outer rotor of the outer rotor coreless motor, and providing the encoder plate with at least one mark of a control timing detecting mark for detecting a signal such as rotation control, or a phase switching signal detecting mark for detecting a phase switching signal for a current applied to a coil of each phase of the outer rotor type coreless motor. With this configuration, the bearing for supporting the encoder plate is not needed, hole devices for switching the motor phases as before are not needed, and the motor coils can be placed without considering the positions for hole devices, thereby improving the motor efficient resulting from an increased coil utilization efficiency. In addition, lead-out lines for wiring hole devices need not be taken into consideration, and the optical detectors can be almost intensively disposed, so that the mounting can be readily performed.

[0107]

The invention set forth in claim 14 is the endless belt driving apparatus according to claim 13, characterized in that the phase switching signal detecting mark is additionally used as a mark for detecting a start signal which is output once per rotation. With this configuration, it is not necessary to additionally provide an independent start angle position detector, and the bearing for encoder of the detector is not needed, thereby realizing a low cost image forming apparatus.

[0108]

[Embodiments of the Invention]

In the following, preferred embodiments of the present invention

will be described with reference to the accompanying drawings.

[0109]

In a high resolution (2400 dpi, 1200 dpi) tandem type color printer or color copier, the eccentricity of photo-sensitive drums and variations in radius are not negligible. In addition, it is necessary to conduct a control such that the peak in a circular cross-section of a photo-sensitive drum is in contact with a conveyer belt at all times, when variations in line density and color combinations are taken into consideration. In other words, an associated control which satisfies such conditions is required. For realizing this with stability, the conveyer belt is most preferably controlled at a uniform speed.

[0110]

Specifically, if the conveyer belt can be controlled to run at a uniform speed under the foregoing conditions, the photo-sensitive drums may be controlled to rotate at a uniform angular speed even if the photo-sensitive drums have eccentricities. It is easy to control the photo-sensitive drums to run at a uniform angular speed. If the conveyer belt or an intermediate transfer belt can be highly accurately controlled to run at a uniform speed, the exemplary configurations described in the section of the prior art can also be supported even if a higher image quality is required so that highly accurate driving must be conducted.

[0111]

In this embodiment, for driving the driving roller to run an endless conveyer belt at a uniform speed, consideration is made on conditions under which a rotating angle encoder alone is used for implementation.

[0112]

When the driving motor is rotated at a uniform angular speed, the eccentricity of the driving roller, if any, would cause the speed of the conveyer belt to fluctuate. However, as described below, fluctuations in the speed of the belt is eliminated if the conveyer belt is maintained at all times in contact with the peak in the circular cross-section of the driving roller. The phrase "the conveyer belt is in contact with the peak in the circular cross-section of the driving roller at all times" means that the conveyer belt is in contact with a straight line in a certain direction passing through the center of the circular cross-section of the driving roller (condition under which this straight line only translates) in perpendicular orientation at all times.

[0113]

In the following, the result of consideration and analysis will be described in connection with embodiments.

· Relationship between Belt Moving Speed and Rotating Angular Speed of Driving Roller (No. 1)

When a belt 1 is in contact with the peak in a circular cross-section of a driving roller 3 at all times -

In Fig. 1, ε represents the amount of eccentricity; and θ the angle of the position of the eccentricity from the x-axis, a speed at which a contact T of the belt 1 with the driving roller moves is represented in coordinates by:

[0114]

[Eq. 25]

$$(-\varepsilon\sin\theta\cdot\omega,\ \varepsilon\cos\theta\cdot\omega),\quad \omega=d\theta/dt$$

[0115]

Thus, the speed Vs of the driving roller 3 rotating about the center O of rotation in a direction S is represented by:

[0116]

[Eq. 26]

$Vs = V\cos\alpha - -\varepsilon\sin\theta\cdot\omega\cdot\cos\alpha + \varepsilon\cos\theta\cdot\omega\cdot\sin\alpha$

where V represents the belt moving speed; and α the angle formed by a line orthogonal to a line r connecting the contact T from the center O of rotation of the driving roller 3 at the position of the contact T to the belt.

[0117]

Therefore,

[0118]

[Eq. 27]

$\omega = Vs/r = (V\cos\alpha - \varepsilon\sin\theta\cdot\omega\cdot\cos\alpha + \varepsilon\cos\theta\cdot\omega\cdot\sin\alpha)/r$

is established. Here, from the cosine law:

[0119]

[Eq. 28]

$r^2 = R^2 + \varepsilon^2 - 2R\varepsilon\sin(\pi/2-\theta) = R^2 + \varepsilon^2 - 2R\varepsilon\sin\theta$

where R is the radius of the drum.

[0120]

Here, from the sine law:

[0121]

[Eq. 29]

$\varepsilon/\sin\alpha = r/\sin(\pi/2-\theta) = r/\cos\theta$

[0122]

[Eq. 30]

$\sin\alpha = \varepsilon\cos\theta/r$, $\cos\alpha = (R-\varepsilon\sin\theta)/r$

Substituting (Eq. 28), (Eq.29) and (Eq. 30) into (Eq. 27):

[0123]

[Eq. 31]

$$\omega = (VR - (V+\omega R) - \varepsilon\sin\theta + \omega\,\varepsilon^2\} / (R^2 + \varepsilon^2 - 2R\varepsilon\sin\theta)\,\omega(R^2 + \varepsilon^2 - 2R\varepsilon\sin\theta)$$

$$= VR - (V+\omega R)\varepsilon\sin\theta + \omega\,\varepsilon^2(\varepsilon\sin\theta - R)(V-R\omega) = 0$$

$$\varepsilon\sin\theta - 0R$$

Thus, the relationship of $V=R\omega$ is established.

[0124]

In other words, even if the driving roller 3 has an eccentricity, the belt speed V is constant if the rotating angular speed of roller is constant, and if there is no slippage of the conveying belt 1. However, there is a necessary condition that the conveyer belt 1 must be held horizontal. Generally, in the relationship between the photo-sensitive drums 5 and the conveyer belt 1 as illustrated in Fig. 23, since the conveyer belt 1 extends on both sides with respect to the contact, a state close to this condition is readily realized. However, since the belt extends only on one side of the driving roller 3, some technique is required for realizing this condition.

[0125]

A first embodiment for the foregoing involves providing a roller having the same diameter as the diameter of the driving roller in close proximity to the driving roller and photo-sensitive drum and in contact with the conveyer belt, and matching the phase of eccentricity. By doing so, fluctuations in the belt speed is mitigated when the driving roller is controlled to rotate at a constant angular speed. However, in this event, since even slight variations in the diameter of the adjacent roller causes the phase to shift little by little over time, the roller in close proximity to the driving roller is connected to a gear or the like to prevent the phase from

shifting.

[0126]

A second embodiment is a method which involves measuring the angle and magnitude of the eccentricity of the driving roller, and controlling the roller in close proximity to the photo-sensitive drum to move up and down in a direction perpendicular to the running conveyer belt. In this event, it is necessary to maximally reduce the eccentricity of the adjacent roller.

[0127]

A third embodiment is a method, employed when the first or second embodiment is not desired, which involves ensuring a machining accuracy and an assembling accuracy for the driving roller and roller such that the eccentricity of the roller in close proximity to the photo-sensitive drum and the driving roller is to such a degree that the conveying belt falls within target speed fluctuations. The adjacent roller may comprise two rollers which sandwich the belt.

[0128]

Further, a fourth embodiment is a method which involves ensuring the machining accuracy and assembling accuracy for the driving roller such that the eccentricity of the driving roller is to such a degree that the conveying belt falls within target speed fluctuations, and fixing a non-rotatable supporting guide at a location corresponding to the roller in close proximity to the photo-sensitive drum.

· Relationship between Belt Moving Speed and Rotating Angular Speed of Driving Roller (No. 2)

When the belt 1 is not in contact with the peak in the circular cross-section of the driving roller 3 at all times -

As illustrated in Fig. 2, the contact T of the belt 1 with the

driving roller 3 fluctuates due to the eccentricity ε as is the case with Fig. 1. In this event, since the aforementioned condition is not satisfied, the belt speed fluctuates even if the driving roller 3 is rotating at a constant angular speed.

· Method of Assembling and Machining Driving Roller and Roller in Close Proximity to Photo-Sensitive Drum to Reduce Eccentricity to Zero

In the foregoing embodiments, the most simple mechanism is provided by investigating a method of assembling and machining the roller in close proximity to the driving roller near the photo-sensitive drum (adjacent roller) and the driving roller such that the eccentricity is reduced to zero. Generally, an adjusting mechanism can be incorporated because the driving roller and adjacent roller are not removed by a user. If this can be made more accurate than target specifications, the belt can be controlled to run at a uniform speed with a sufficiently high accuracy using a rotating angle encoder method. In regard to the photo-sensitive drum, the method discussed herein cannot be employed because the photo-sensitive drum can be removed for maintenance or the like. As illustrated in Fig. 7, the adjacent roller may comprise two rollers 62 which sandwich the belt.

[0129]

(1) The driving roller and adjacent roller are highly accurately machined before they are assembled and adjusted.

[0130]

The driving roller and adjacent roller are manufactured with a high roundness and a high accuracy for the diameter, such that they can be two-dimensionally adjusted in position as illustrated in Fig.

3. After the adjustment for eccentricity, the dynamic balance is taken. In Fig. 3, an auxiliary roller 50 in pressure contact with a side face of the driving roller 3 is provided, and a driving rotating shaft 51 coupled to the auxiliary roller 50 and driven by a motor, not shown, is rotatably supported by a bearing 52, such that the driving roller 3 is driven to rotate through the auxiliary roller 50. The contact side face of the auxiliary roller 50 is made two-dimensionally movable with respect to the side face of the driving roller 3.

[0131]

The dynamic balance for the driving roller 3 is preferably taken after the motor has been assembled. However, when the rotational speed is slow, the dynamic balance is taken only after the motor has been assembled. Further, at a low speed, the dynamic balance can be omitted. However, if lower power consumption is desired, the adjustment for the dynamic balance is required.

(2) Integral Machining of the Rotating Shaft Extending through Bearing and Driving Roller or Adjacent Roller

As illustrated in Fig. 4, the driving roller 3 is integrally formed with a driving rotating shaft 55 driven by a motor, not shown, so that the driving rotating shaft 55 is rotatably supported by the bearing 52, thereby making it possible to reduce the eccentricity of the driving roller 3. With the adjacent roller, the foregoing can be applied.

[0132]

With the driving roller 3, the rotor of the motor can be directly coupled to the driving rotating shafts 51, 55. When the motor is driven through a gear or a belt, the driving rotating shafts 51, 55

are provided with gears or pulleys.

· Eccentricity of Rotating Angle Encoder

In an encoder for detecting a rotating angle, if a disk with a detection timing mark has an eccentricity, the driving roller cannot be controlled to rotate at a uniform speed by a control for a uniform sped rotating angle conducted by detecting the mark. In this event, it is possible to remove the influence due to the eccentricity of the encoder if all of signals detected by a plurality of timing mark detectors each having a timing mark on a disk arranged at equal angular intervals with respect to the axis of rotation are fed back for control. For removing the influence due to the eccentricity of the encoder using two timing mark detectors, the detectors are disposed in opposition to the axis of rotation of the disk.

· Control Method with Belt Having Timing Mark

The belt can be controlled to run at a uniform speed by detecting a final belt motion to control the rotating motor. However, if the driving pulley has a large eccentricity, the control system is required to have a gain for correcting it. In other words, since the control bandwidth is extended, required mechanical rigidity is higher. Thus, the eccentricity of the driving roller and adjacent roller should be as small as possible.

· Stabilization of Belt Running due to Eccentricity of Photo-Sensitive Drums in Tandem Type Image Forming Apparatus

When a photo-sensitive drum has an eccentricity in a tandem type image forming apparatus, a contact face between the photo-sensitive drum and a belt moves up and down. This apparently causes variations in the distance between the respective photo-sensitive drums, so that the belt is drawn and slacked. For achieving a high image quality,

it is necessary to maintain the condition that the belt is in contact with the photo-sensitive drum at the peak position in the circular cross-section of the photo-sensitive drum to correct the apparent variations in the distance between the drums.

[0133]

Specifically, as illustrated in Fig. 5, there are provided rollers 60 for urging the belt 1 onto the photo-sensitive drums 5, and tension rollers 61 for adjusting the tension of the belt 1 resulting from upward and downward movements of the belt 1 due to the eccentricity of the photo-sensitive drums 5, and a pair of rollers 62 having fixed rotating shafts are provided for holding a constant running position for the belt 1. The tension rollers 61 act as springs 64 for applying an urging force. By thus configuring, it is possible to hold a constant slack or tensioned state of the belt 1, so that the belt 1 can be in contact with the photo-sensitive drum 5 at the peak position in the circular cross-section of the photo-sensitive drum at all times. Then, the roller 60 is implemented by a tension roller structure which has springs 63 provided on both sides of a transfer position of the photo-sensitive drum 5 such that the belt 1 more accurately comes into contact with the photo-sensitive drum 5 at the peak position in the circular cross-section of the photo-sensitive drum 5.

[0134]

Fig. 6 omits the fixed roller pair 62 by properly establishing the relationship between spring forces, wherein rollers 65 for urging the belt 1 onto the photo-sensitive drum 5, and tension rollers 66 for adjusting the tension of the belt 1 are provided, and the rollers 65 and tension rollers 66 are coupled to springs 67, 68, respectively. In Fig. 6, the rollers 65 provided to sandwich a transfer position

of the photo-sensitive drum 5 for applying a pressure to the image transfer position in the photo-sensitive drum 5 may be fixed rollers which have fixed rotating shafts and are therefore unrotatable. In this event, the condition that the belt 1 is in contact with the photo-sensitive drum 5 at the peak position in the circular cross-section of the photo-sensitive drum 5 is slightly released, but they can be employed when a target quality can be still maintained thereby.

[0135]

Fig. 24 illustrates a specific exemplary configuration of the rollers 60, 65 and tension rollers 61, 66. A spring force urging mechanism in this configuration is disposed on both sides (in a direction perpendicular to the belt running direction, i.e., the depth direction in the figure) or one side of the belt 1. The rollers 60, 65 and tension rollers 61, 66, or the driving roller 3 has a length equal to or larger than the width of the belt 1. Alternatively, in another embodiment, each of the rollers 60, 65, 61, 66, 3 may be distributed near both ends of the belt.

[0136]

Fig. 7 illustrates the configuration using a highly accurate driving roller which has the eccentricity and diameter that fall under a target accuracy. A pair of rollers 62 closest to the driving roller 3 also have a high accuracy with their eccentricities and diameter falling within a target accuracy. In this way, when the driving roller 3 is controlled to rotate at a constant speed, the belt 1 can be stably moved at a uniform speed even if any of the photo-sensitive drums 5 has an eccentricity. The driven roller side on the opposite side of the driving roller 3 is also configured as illustrated in

Fig. 7. By doing so, the driven roller side will not cause any problem even if the accuracy for the eccentricity and diameter is lower than that on the driving roller side. However, fluctuations in load can be reduced with a higher accuracy. In Figs. 5 - 7, the rollers 60, 65, and 61, 66 may include elastic members on the respective outer peripheries thereof which are in contact with the belt in order to produce a similar effect to springs.

· Highly Accurate Driving Roller Driving Mechanism

A configuration employed in the prior art comprises a transmission mechanism such as a gear or a belt used for decelerating a motor; and a fly wheel mounted to a driven roller, which is to be controlled, or to a rotating shaft of a photo-sensitive drum, as described in Laid-open Japanese Patent Application No. 10-63059 to limit vibrations produced in a transmission system and the like. While this configuration advantageously improves the motor efficiency, the transmission system incorporated in the driving system includes such problems as lower rigidity of the transmission system, and eccentricity, thereby making it difficult to highly accurately control the driving roller to rotate at a constant speed.

[0137]

While a motor comprising a core having a coil wound around a slot yoke of a stator has been commonly used for a driving motor, this motor generates cogging. Laid-open Japanese Patent Application No. 6-271130 describes an exemplary configuration which employs a pulse motor. This motor also has a similar phenomenon. Therefore, if a motor in this configuration is directly coupled to a driving roller, fluctuations in speed appear as they are. As such, an ideal configuration will have a direct-coupled coreless motor which does

not generate cogging. As compared with a driving method having a transmission mechanism, the direct-coupling method can reduce the power consumption for a driving system in a tandem type color printer or color copier by absorbing fluctuations in a variety of loads to the respective photo-sensitive drums using motors provided for the respective photo-sensitive drums, though the motor efficiency is lower. Thus, the direct-coupling method can provide a highly accurate driving control, as well as can reduce the size of the driving mechanism for the driving roller and simplify the driving mechanism.

[0138]

Bearings are commonly used for supporting rotating parts of motors, driving rollers, and encoders. Also, an outer rotor type motor may be employed to increase the inertia, expecting a fly-wheel effect, which is the prior art, and also produces effects described below.

[0139]

As one embodiment, the outside (outer peripheral surface) of the outer rotor of the motor can be used as a driving roller, as illustrated in Fig. 8. In Fig. 8, 70b designates a rotating shaft (fixed shaft); 71, an outer rotor having a belt 1 wound around the outer periphery thereof; 72, a stator; 73, a coil; 74, a permanent magnet and a yoke; 75, a bearing which rotates on the fixed shaft 70b; 76, a holding member for the bearing 75; 77, an encoder plate provided with a timing mark; 78, a light reflection detection type detector for encoder; and 100, a roller having the same diameter as the outer rotor and formed concentrically with the same. The roller 100 holds the belt 1 as well as transmits a driving force to the belt 1 by the action of friction.

[0140]

By doing so, highly accurate multi-functional parts can be integrated. In addition, it is also possible to provide a similar structure to the foregoing at the end of the belt 1 opposite to the end. The driving at both ends eliminates twisting, as compared with the driving at one end, so that the rigidity of the roller can be set lower. In other words, the roller 100 can be reduced in thickness. The problem of resonance can be reduced due to low twist rigidity of a transmission shaft 70a in Fig. 9, as compared with the configuration in which the driving roller 3 is disposed separately from the outer rotor 71, as illustrated in Fig. 9 (in the following description, members described in Fig. 8 are designated the same reference numerals, and detailed description thereon is omitted).

[0141]

In Laid-open Japanese Patent Application No. 6-271130, a motor is formed across the overall interior of a driving roller (from one end to the other end). In other words, the motor is formed even in an image forming region of a roller. In doing so, a belt is heated by heat of the motor to affect a transferred toner image in an intermediate transfer belt method, resulting in a degraded image quality. In contract, the configuration of this embodiment can avoid such a trouble, and can reduce the width of the apparatus because the outer rotor of the motor also holds the belt.

[0142]

As another embodiment, as illustrated in Figs. 10, 11, the driving roller 3 (100) may be coupled to an end face of the outer rotor 71. Particularly, when the driving roller 3 cannot be increased in diameter, the coupling of the driving roller 3 to the end face of the outer rotor 71 is more recommendable. The configuration as

illustrated in Figs. 10, 11 is also preferable when a driving torque of a motor is increased. A larger diameter of a motor results in a correspondingly larger fly-wheel effect. Also, the problem of the rigidity in the transmission shaft 70a can be mitigated over the conventional configuration which drives the driving roller 3 through the transmission shaft 70a. In the configuration which directly couples the driving roller in the inner rotor method, the rigidity in terms of the coupling is reduced because of a smaller area of the coupled parts, as compared with a motor implemented with the same geometry as the outer rotor 71.

[0143]

Since an encoder is designed in consideration of the problem of heat, the material for the encoder plate 77 must be selected in consideration of the heat resistance. For example, a metal plate is preferable.

[0144]

The encoder plate 77 and the detector 78 for the encoder in Figs. 8, 10 and 11 may be disposed outside, as in Fig. 9. This configuration is preferable for mitigating the influence of heat within the motor. However, since the driving roller 3 is spaced away from the outer rotor 71 of the motor, it is necessary to sufficiently consider the rigidity of the transmission shaft 70a (material, diameter).

[0145]

While Figs. 8, 10 illustrate exemplary positioning for the outer rotor type bearing, it may be modified as illustrated in Fig. 11 to use an inner rotor type bearing. When using the outer rotor type bearing in Figs. 8, 10, the shaft 70b is not rotated but fixed. Also, in Figs. 10 and 11, the yoke 74 of the outer rotor 71 of the motor

and the driving roller 3 may be integrally machined with a magnetic material, or the yoke of the outer rotor 71 and a member for holding the permanent magnet 74 may be integrally machined to permit more stable driving.

[0146]

Also, the accuracy is further improved when the dynamic balance is taken with the motor being integrated with the driving roller.

[0147]

This concept can be employed not only in the belt driving but also in the driving in the photo-sensitive drum. Assume that the driving roller 3 in Figs. 9 - 11 is replaced with the photo-sensitive drum 5. Assume in Fig. 8, the belt 1 is replaced with the photo-sensitive drum 5. However, the photo-sensitive drum must be changed when it is deteriorated. In the configurations of Figs. 10 and 11, a plurality of taps (protrusions) are provided on an end face of the outer rotor, and holes (recesses) on the end face of the photo-sensitive drum are fitted onto the taps for realization. In the configuration of Fig. 8, the outer rotor may be introduced into the cavity of the photo-sensitive drum, and fixed using a screw for preventing slippage in the rotating direction.

· Structure of Outer Rotor Type Coreless Brushless Motor

Figs. 12 and 13 illustrate exemplary structures of an outer rotor type coreless brushless motor. Fig. 12 illustrates an outer rotor 71 which has a yoke 74a, part of which is cut out, and permanent magnets 74b. The permanent magnets 74b are arranged on the inner peripheral side, and magnetic poles oriented to the center alternately have the N-pole and S-pole in the circumferential direction for magnetization, or magnets having the polarities are arranged. The yoke 74a is

disposed on the outer peripheral side.

[0148]

Fig. 13 illustrates an exemplary structure of a stator having a yoke 80 and coils 81. In this example, a bundle of coils are arranged side by side, as illustrated in Fig. 14. Fig. 15 illustrates how the coils are arranged. Specifically, the bundle of coils as illustrated in Fig. 14 are arranged around the stator in a direction in which the outer rotor moves, with the phase being shifted. This example shows the arrangement of three-phase coils A, B, C. Permanent magnets, which make up the outer rotor, are arranged around the yoke with alternating polarities, so hat they move as indicated by an arrow in Fig. 5 when the motor is rotated.

[0149]

When the pitch of one pole (S-pole or N-pole) of a permanent magnet in a motor is P, the bundle width Cw of the coil bundle (width in a direction perpendicular to the direction in which the rotor rotates) is P/3, and the center-to-center distance of the bundle width Cw to the left and right in the figure is P. While both ends representing a piling state of the coil bundle are shown to be piled and stopped for facilitating the understanding, they are actually piled in continuation. For connecting these coil bundles to provide three phases, every third coils are connected for one phase.

[0150]

Fig. 15 only shows a connection method for a coil C. For making even a thrust generating direction with respect to a current flow direction in the coil C, in odd-numbered and even-numbered coil bundles, for alternately changing the current flow direction, the connection to two coil terminals in Fig. 14 is changed in even-numbered

ones and odd-numbered ones. This is because the direction of linking magnetic field is opposite in the even-numbered coil bundles and odd-numbered coil bundles.

[0151]

Further, in Fig. 15, 83 designates hole sensors (hole devices) each for sensing the strength and direction of a magnetic field which passes above the sensor. The strength of a moving magnetic field generated by a yoke 74a on the rotor, the permanent magnet 74b, and the stator yoke is shown, where a sinusoidal waveform and a trapezoidal waveform are shown in the figure. While a coreless motor does not generate cogging, it does generate torque ripple by a change in the shape of the strength of a magnetic field. As will be later described, when this shape is brought as close as possible to a trapezoid having a long linear portion, a resulting motor can be highly efficient with reduced torque ripple. Generally, the image quality is less affected when a fluctuation spatial frequency due to vibrations in the driving system is lower but is more susceptible as the frequency is higher, has an extreme value, and is again less affected as the frequency is higher. Such characteristics are known. Of course, the image quality is higher as the torque ripple is smaller.

[0152]

Also, because of a three-phase motor, when the peripheral length of the permanent magnets of the rotor is represented by L, L/2P=n (natural number) pairs of N-pole and S-pole are created, so that the basic spatial frequency fs of the torque ripple is represented by (Eq. 32):

[0153]

[Eq. 32]

$fs = 6n/(\pi D)$

(where D represents the diameter of the driving roller.)

Smaller n results in a lower basic frequency of the torque ripple and a lower susceptibility to a degraded image quality. However, excessively small n would cause a need for a thicker yoke 74a for the outer rotor. Specifically, as the permanent magnet of one pole has a larger width as in Fig. 16, an increased amount of magnetic flux passes through the yoke 64a and goes into the adjacent permanent magnet 74b, so that a magnetic path must be make wider for passing the magnetic flux therethrough. An arrow in Fig. 16 indicates the flow of the magnetic flux. For this reason, the rotor has increased inertia.

[0154]

However, since the stability for a steady-state operation for rotating at a constant speed is more important for the driving system of a printer or a copier, for example, this is not a disadvantage. Rather, larger inertia is more convenient. For providing the same thrust, the outer rotor type has rotating parts more outside than the inner rotor type, so that rotating inertia becomes larger, as a matter of course. With a printer or a copier, the outer roller type is advantageous in this respect as well.

[0155]

Also, as the driving roller has a larger diameter, the basic spatial frequency fs of torque ripple is smaller, but loads transmitted from the belt to the driving roller must be taken into consideration for the diameter. As the driving roller is larger for the same motor torque, a belt tension force is weaker.

[0156]

On the other hand, when an allowable outer diameter of a motor is determined, a magnetic circuit gap should be as close as possible to the outer periphery in order to generate a large torque for the same thrust. In this regard, the value n in (Eq. 32) must be larger.

[0157]

Therefore, though depending on the setting of the diameter of the driving roller, an optimal value for n is found at the highest possible basic spatial frequency fs of the torque ripple at which the torque ripple amplitude value is acceptable at each torque ripple frequency. While it is contemplated to increase n to provide a higher torque ripple frequency for realization, the magnetic pole pitch of magnet is excessively small, and the coil bundles are also extremely thin, thereby making the manufacturing of the motor difficult. Also, since the motor driving frequency is higher, a variety of losses increase so that the control is more difficult.

[0158]

Fig. 17 is a diagram showing an allowable vibration amplitude in the sub-scanning direction (belt moving direction) for providing a high image quality. In Fig. 17, the vertical axis represents the vibration amplitude, the horizontal axis represents the vibration spatial frequency of the driving system, and a thick line indicates the allowable vibration amplitude region. The vibration spatial frequency in Fig. 17 corresponds to the torque ripple spatial frequency fs which is calculated from (Eq. 32). When a gear is included as a transmission mechanism as in the prior art, the torque fluctuation frequency due to the torque ripple or cogging of the motor increases by a factor of the gear ratio, making it difficult to set in a lower region in Fig. 17. As such, the gear ratio must be larger

in order to set in a higher region. This is because the gear-based transmission mechanism causes a larger vibration amplitude. A larger gear ratio means a more complicated apparatus. In this embodiment, the torque ripple is set in the lower region, unlike the prior art. The consideration made herein can be applied as well when the photo-sensitive drum is driven. In other words, the torque ripple frequency can be calculated by replacing the diameter of the driving roller with the diameter of the photo-sensitive drum in (Eq. 32).

[0159]

Fig. 18 is a diagram showing the relationship between the coil and the magnetic field, showing only one side of coil bundles in each phase (only the left side in Fig. 14) for facilitating the explanation of the principles, showing odd-numbered positions on the lower side and even-numbered positions on the upper side for facilitating the understanding of the figure, and showing the waveform of the magnetic field as a triangular waveform. Since the coil on the stator yoke is not movable, the magnetic field moves as shown during the rotation of the motor (on the assumption that the magnetic field moves from right to left). The coil bundles on the return side, not shown in Fig. 18, are arranged such that the shown coil bundles on the left side is just in the opposite direction to the magnetic field linking to the current flow, so that the same thrust is generated.

[0160]

As indicated by an arrow in Fig. 18, in an even-numbered coil bundle, a current is applied from a timing at which a zero-cross of the rising edge of the waveform of the magnetic field intersects with the left-hand end of the coil bundle until the magnetic field moves by 2P/3 and the zero-cross of the falling edge of the waveform of

the magnetic field passes the right-hand end of the coil bundle, to generate a rotating thrust. In this event, in an odd-numbered coil bundle, a current flows from the falling edge of the magnetic field to the rising edge, and the connection between the coil bundles has been made as mentioned above, and the current flow is in the opposite direction to the even-numbered one with the linking magnetic field being opposite as well, so that the direction of the generated thrust matches with the even-numbered coil bundle. After the magnetic field has advanced by P/3 from here, in the even-numbered coil bundle, a current flows in the opposite direction to the foregoing from the falling edge to the rising edge of the magnetic field. Since the coil is fixed to the stator yoke, the rotor moving direction is opposite to the generated thrust. Bearing this in mind, a current is applied in a direction in accordance with the left hand rule of Flemming.

[0161]

As illustrated in Fig. 15, since the coil bundles in each phase are connected, the ON-OFF timing and the direction of a current applied to each coil, when the motor is rotated at a uniform speed, are as shown in Fig. 19. The detection of this timing and the direction in which the current is applied can be carried out by providing one hole sensor 83 for each phase at an end position of the coil bundle at which the magnetic flux can pass through the hole sensor 83.

[0162]

Fig. 15 shows specific examples of positions at which the hole sensors 83 are disposed. Since the hole sensor 83 generates an output proportional to the strength of magnetic flux, the ON-OFF timing and direction of a current applied to each coil phase can be controlled by detecting the output.

[0163]

Fig. 20 illustrates a general H-shaped circuit for controlling the ON-OFF timing and the direction of a current applied to one coil phase (showing an A-phase in the figure), and a current value. When A1, A2 inputs are turned ON substantially at the same time, a current flows into the coil. When INVA1 and INVA2 are turned ON substantially at the same time, a current flows in the opposite direction. A CNT input controls a current value applied to the motor. In the control system of Fig. 33, it is necessary to detect the counter-electromotive force of the motor. In Fig. 20, a resistor is additionally connected in series with each coil to detect a voltage at the end of the coil and a terminal voltage across the resistor in each coil. A voltage proportional to the rotational speed of the motor can be detected by processing and combining the detected voltages.

[0164]

Fig. 21 shows the strength of magnetic flux linking to the coils superimposed on Fig. 19, when the waveform of the moving magnetic field is triangular and trapezoidal. Assuming that the driving current value is constant, the product of the current waveform and magnetic flux in Fig. 21 represents a thrust as it is. While the realization is difficult, an ideal triangular waveform, for example, results in a constant combined thrust of the three coil phases at all times. However, since the constant current is applied even to a location at which the strength of the magnetic field is low, the efficiency is correspondingly reduced. When the magnetic field is in a shape close to a sinusoidal wave, the efficiency of the motor is lower, and ripple occurs in the combined thrust.

[0165]

While the thrust ripple also occurs in the case of trapezoidal waveform shown in Fig. 21, the current may be applied independently such that each coil is not simultaneously applied with the current, and a current switching time from one phase to another may be minimized, resulting in a motor which is efficient and generates small thrust ripple.

[0166]

While the foregoing embodiment has been described in connection with an example which employs the hole sensors 83, it is also contemplated to provide a sensor having the same function as the hole sensor on the encoder. Specifically, this is realized by adding a mark on the encoder plate, and detecting the mark. In this event, the same number of optical detectors of the encoder as the hole sensors may be provided for switching the phases, and three in this embodiment. Then, the marks are added in accordance with the magnetic flux in the gap of the rotating magnetic circuit.

[0167]

Specifically, when the flux is oriented in the plus direction (N-direction) in Fig. 15, a reflective mark is added, whereas light transmits when in the minus direction. The relationship between the orientation of the magnetic field and the mark may be reversed. Then, the mark is put on the encoder plate, and when the encoder plate is assembled into the outer rotor, a zero-cross point of the direction of the magnetic field in the gap and the magnetic field matches with a switching point of the presence/absence of the mark and a marked point and a markless point. The detectors of the encoder are disposed corresponding to the arrangement of each coil phase as is the case

with the hole sensors. When optical detectors are employed, it is not necessary to place the detector at a position at which it links to the magnetic flux, and therefore it is not necessary to arrange coils in consideration of attachment, as is the case with the hole devices, and the coil length related to the generation of thrust can be laid out long, so that a more efficient motor can be manufactured.

[0168]

Further, for optical detection, one detector for detecting the mark can be used as a reference angular position detector (start position detector) for one rotation. While it is possible with a hole sensor, it is difficult to increase the positional accuracy by suddenly rising the waveform. Therefore, when a high accuracy is required, an extra detector must be provided. On the other hand, in an optical strategy, it is possible to devise techniques such as narrowing down a beam irradiated to the encoder plate, forming a slit on the detection side, and the like, so that a highly accurate reference angular position detector can be implemented without increasing the number of detectors.

[0169]

Fig. 22 illustrates an exemplary configuration of an encoder with n=2 which specifically realizes the foregoing. Fig. 22(a) is a diagram illustrating an encoder plate 90 which is provided with a plurality of timing marks for detecting the rotating angle (only one of which is described in the figure) 91 arranged in the circumferential direction, and marks 92 corresponding to the magnetic field generated by the rotor. Fig. 22(b) is a diagram illustrating the layout of detectors for the encoder plate 90, where three detectors 93 for detecting a position at which the magnetic field changes, and a timing

detector 94 are provided. One of the detectors 93 for detecting a position at which the magnetic field changes is implemented as a start angular position detector.

[0170]

Since the detectors can be intensively arranged to facilitate the wiring, there is an effect of facilitating the implementation. A detector 95 indicated by a broken line in Fig. 22(b) is attached to the encoder when a large eccentricity is found, as has been conventionally known, for simultaneously detecting timing signals 180° out of phase, which are used for a control to remove the influence of the eccentricity.

[0171]

[Effects of the Invention]

As described above, according to the present invention, the stable and accurate belt uniform speed control is realized by setting a small allowable eccentricity for the roller to an extent that it does not affect fluctuations in the belt speed and by controlling the driving roller to rotate at a uniform angular speed.

[0172]

Also, a highly accurate dynamic balance can be taken in the driving roller portion on the belt to achieve stable uniform angular speed control, thereby more stably controlling the belt to run at a uniform speed.

[0173]

Even if a belt rotating body has an eccentricity, it is possible to prevent such phenomena as a sagged belt to consequently prevent slippage between the belt and the rotating body, permitting a stable integral motion of the rotating body with the belt.

[0174]

Also, the belt can highly accurately come into contact with the rotating body at the peak position in the circular cross-section of the rotating body, so that even if the rotating body has an eccentricity, an associative control can be carried out by controlling the rotating body to rotate at a uniform speed, provided that the belt runs at a uniform speed. In other words, the rotating body can be moved at a readily controllable uniform angular speed for the associative control.

[0175]

It is also possible to eliminate such problems as fluctuations in transmission speed due to gears and the drive transmission belt, which are included in a rotation driving force transmission system, vibration, and degraded transmission rigidity. Moreover, a setting can be made in a region in which a high motor efficiency is provided without the influence of degraded image quality due to the amplitude of torque ripple and fluctuations in frequency, thereby realizing an image forming apparatus which is small in size and provides a high image quality.

[0176]

It is also possible to eliminate degraded twist rigidity which occurs when a driving torque by a motor is transmitted to the driving roller through a coaxial shaft of the motor, to realize higher rigidity, conduct a stable and highly accurate control, facilitate adjustments for the dynamic balance through the integration of the outer rotor of the motor with the driving roller, realize an image forming apparatus which provides a high image quality, reduce the cost by reducing the number of used bearings, facilitate the machining, and

reduce the size.

[0177]

It is also possible to reduce fluctuations in torque due to the generation of torque ripple of the motor and improve the motor efficiency as well, thereby realizing an image forming apparatus which provides lower power consumption and a high image quality.

[0178]

On the encoder plate, a control timing detecting mark for detecting a signal such as rotation control, or a phase switching signal detecting mark for detecting a phase switching signal for a current applied to the coil of each phase of the outer rotor type coreless motor, or the phase switching signal detecting mark is shared as a mark for detecting a start signal which is output once per rotation, thereby making it possible to eliminate the need for hole sensors for switching the motor phase, and dispose the coils without consideration on the positions of the hole sensors. The resulting increase in the coil utilization efficiency causes a higher motor efficiency. Hole sensor wiring lead-out lines need not be taken into consideration, and most of optical detectors can be intensively arranged, thereby facilitating the mounting thereof. In addition, a sensor for detecting a start angular position need not be provided independently, and a bearing for the encoder is also eliminated, thereby realizing a low cost image forming apparatus.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

An explanatory diagram of the relationship between a belt and a driving roller for describing an embodiment of the present invention (when the belt is in contact with the peak in a circular cross-section

of the driving roller at all times).

[Fig. 2]

An explanatory diagram of the relationship between the belt and the driving roller when the belt is not in contact with the peak in the circular cross-section of the driving roller at all times.

[Fig. 3]

An explanatory diagram of an exemplary configuration of a driving roller and an auxiliary roller in an embodiment of the present invention.

[Fig. 4]

An explanatory diagram of another exemplary configuration of the driving roller and auxiliary roller in an embodiment of the present invention.

[Fig. 5]

An explanatory diagram of an exemplary configuration illustrating the relationship among photo-sensitive drums, rollers, and a belt in an embodiment of the present invention.

[Fig. 6]

An explanatory diagram of another exemplary configuration illustrating the relationship among the photo-sensitive drums, the rollers, and the belt in an embodiment of the present invention.

[Fig. 7]

An explanatory diagram of an exemplary configuration illustrating the relationship among the photo-sensitive drums, the rollers, a driving roller, and the belt in one embodiment of the present invention.

[Fig. 8]

A cross-sectional view illustrating a relational configuration

of an outer rotor type coreless motor with the belt in an embodiment of the present invention.

[Fig. 9]

A cross-sectional view illustrating a relational configuration of a conventional outer rotor type coreless motor with a belt and a driving roller.

[Fig. 10]

A cross-sectional view illustrating a relational configuration of the outer rotor type coreless motor with the belt and driving roller in an embodiment of the present invention.

[Fig. 11]

A cross-sectional view illustrating a relational configuration of the outer rotor type coreless motor with the belt and driving roller in one embodiment of the present invention.

[Fig. 12]

A perspective view illustrating an outer rotor of the outer rotor type coreless motor in an embodiment of the present invention.

[Fig. 13]

A perspective view illustrating a stator of the outer rotor type coreless motor in an embodiment of the present invention.

[Fig. 14]

An explanatory diagram of a coil of the outer rotor type coreless motor in an embodiment of the present invention.

[Fig. 15]

A configuration diagram for explaining a portion of the outer rotor type coreless motor in which the coils are arranged in an embodiment of the present invention.

[Fig. 16]

An explanatory diagram illustrating the flow of magnetic flux in a yoke and magnets in the outer rotor type coreless motor.

[Fig. 17]

An explanatory diagram showing the relationship between an allowable critical amplitude for vibrations of a driving system and a spatial frequency for providing a high image quality.

[Fig. 18]

A diagram illustrating the relationship between the coils and the magnetic field in the outer rotor type coreless motor.

[Fig. 19]

An explanatory diagram of an ON-OFF timing for a current applied to each coil of the outer rotor type coreless motor, and the direction in which the current flows.

[Fig. 20]

A configuration diagram of a circuit for controlling a current value applied to each coil of the outer rotor type coreless motor, an ON-OFF timing, and the direction.

[Fig. 21]

A diagram showing the strength of magnetic flux linking to the coils when the waveform of a moving magnetic field is triangular and trapezoidal in the outer rotor type coreless motor, where the diagram is superimposed on Fig. 19.

[Fig. 22]

A diagram for explaining the configuration of an encoder additionally provided with a detection mark in an embodiment of the present invention.

[Fig. 23]

A diagram illustrating an exemplary configuration of the

photo-sensitive drum and a conveyer section in a tandem type image forming apparatus.

[Fig. 24]

A configuration diagram of a spring urging mechanism in a tension roller in Fig. 23;

[Fig. 25]

An explanatory diagram of a relational configuration of the photo-sensitive drum to a conveyer belt.

[Fig. 26]

An explanatory diagram of a relational configuration of the photo-sensitive drum with the conveyer belt or an intermediate transfer belt in the prior art.

[Fig. 27]

An explanatory diagram of a rotating angle from an exposure time to a transfer position when there is an eccentricity and variations in diameter in the photo-sensitive drum.

[Fig. 28]

An explanatory diagram illustrating a plan view of an exemplary configuration for explaining a control configuration in a tandem type image forming apparatus.

[Fig. 29]

An explanatory diagram of a reference mark and a test mark on the conveyer belt.

[Fig. 30]

A diagram illustrating an exemplary configuration of the photo-sensitive drum, a signal detection system for a belt driving system, and a driving system including a motor and a roller.

[Fig. 31]

A configuration diagram of a spring urging mechanism for a load fluctuation correcting motor in Fig. 30.

[Fig. 32]

A configuration diagram of a control system in the driving roller in Fig. 30.

[Fig. 33]

A configuration diagram of a rotation control system in the load fluctuation correcting motor in Fig. 30.

[Fig. 34]

A configuration diagram of a circuit for calculating a clock frequency of a reference input in a load fluctuation correction rotation control system in Fig. 30.

[Description of Reference Numerals]

1 Conveyer Belt

2 Driven Roller

3 Driving Roller

4 Tension Roller

5 Photo-Sensitive Drum

9 Pressure Roller

50 Auxiliary Roller

51, 55 Driving Rotating Shafts

60, 65 Rollers

61, 66 Tension Rollers

62 Roller Pair

70a Rotation Driving Shaft (Transmission Shaft)

70b Rotation Supporting Shaft (Fixed Shaft)

71 Outer Rotor

72 Stator

73, 81 Coils

74a Yoke

74b Permanent Magnet

77, 90 Encoder Plates

78 Detector for Encoder

80 Stator Yoke

83 Hole Sensor

91 Timing Mark for Detecting Rotating Angle

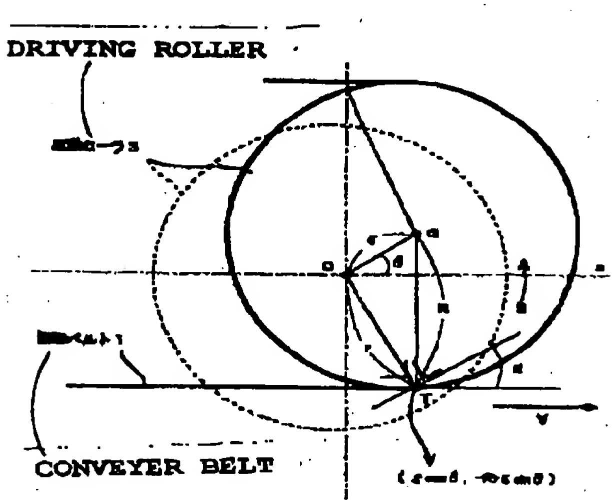
92 Magnetic Field Corresponding Mark

93 Detector

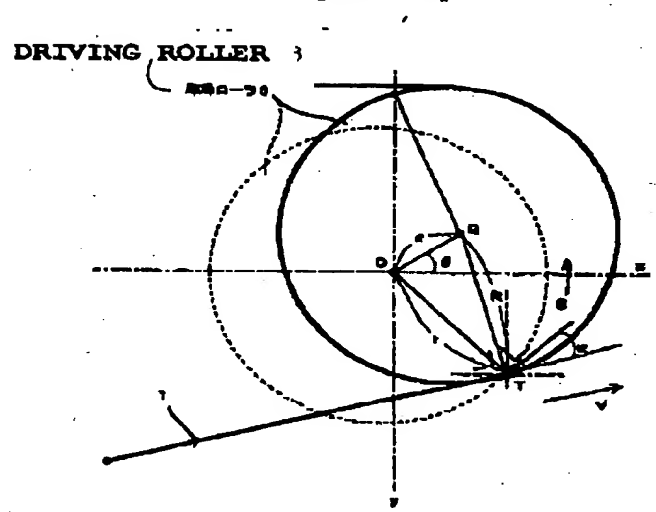
94 Timing Detector

の説明図
【図２０】アウターロータ型コアレスモータの各コイルに流す電流値とＯＮ－ＯＦＦタイミングと方向を制御する回路の構成図
【図２１】アウターロータ型コアレスモータにおいて移動磁界波形を三角形と台形としたときのコイルと鎖交する磁束の強さを図１９に重ねて示した図
【図２２】本発明の実施形態における検出マークを付設したエンコーダの構成を説明するための図
【図２３】タンデム型画像形成装置における感光体ドラムと搬送部の構成例を示す図
【図２４】図２３のテンションローラにおけるばね付勢機構の構成図
【図２５】感光体ドラムと搬送ベルトとの関連構成の説明図
【図２６】感光体ドラムと搬送ベルトあるいは中間転写ベルトとの従来技術の関連構成の説明図
【図２７】感光体ドラムに偏心と径のばらつきがある場合の露光時から転写位置までの回転角の説明図
【図２８】タンデム型画像形成装置における制御構成を説明するための構成例の平面状態を示す説明図
【図２９】搬送ベルトにおける基準マークとテストマークの説明図
【図３０】タンデム型画像形成装置における感光体ドラムとベルト駆動系の信号検出系とモータとローラを含む駆動系の構成例を示す図
【図３１】図３０の負荷変動補正用モータのばね付勢機構の構成図
【図３２】図３０の駆動ローラにおける制御系の構成図
【図３３】図３０の負荷変動補正用モータにおける回転制御系の構成図
【図３４】図３０の負荷変動補正回転制御系における基準入力のクロック周波数を求めるための回路の構成図
【符号の説明】
１　搬送ベルト
２　従動ローラ
３　駆動ローラ
４　テンションローラ
５　感光体ドラム
９　圧接ローラ
５０　補助ローラ
５１，５５　駆動回転軸
６０，６５　ローラ
６１，６６　テンションローラ
６２　ローラ対
７０ａ　回転駆動軸（伝達軸）
７０ｂ　回転支持軸（固定軸）
７１　アウターロータ
７２　ステータ
７３，８１　コイル
７４ａ　ヨーク
７４ｂ　永久磁石
７７，９０　エンコーダ盤
７８　エンコーダ用検出器
８０　ステータヨーク
８３　ホールセンサ
９１　回転角度検出用タンミングマーク
９２　磁界対応マーク
９３　検出器
９４　タイミング検出器

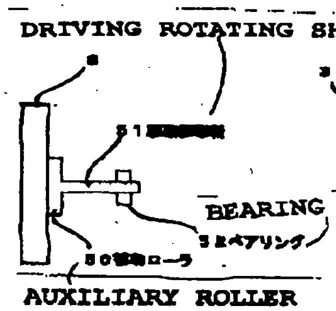
[FIG. 1]



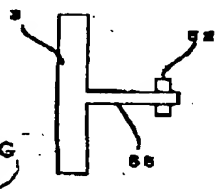
[FIG. 2]



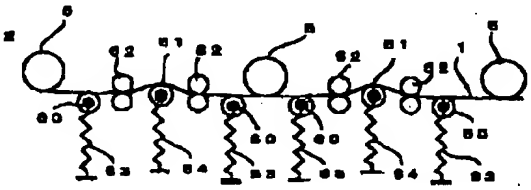
[FIG. 3]



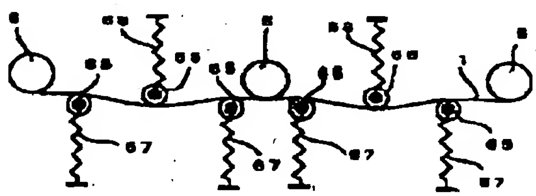
[FIG. 4]



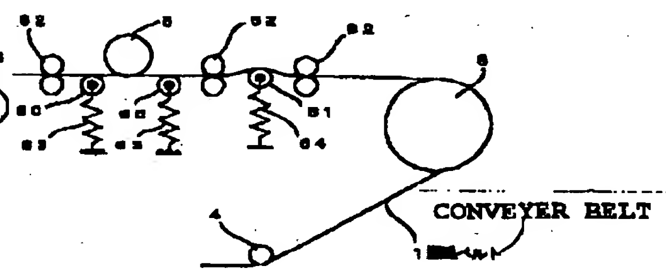
[FIG. 5]



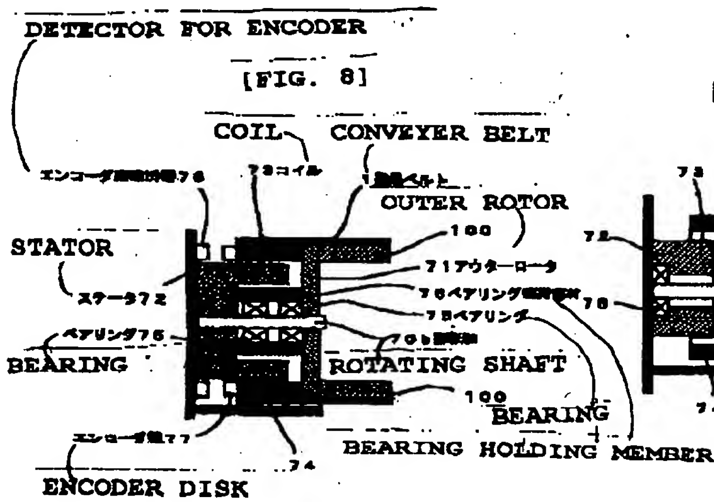
[FIG. 6]



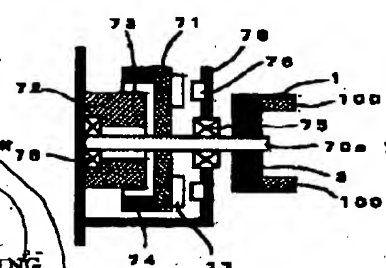
[FIG. 7]



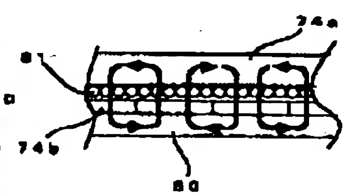
[FIG. 8]



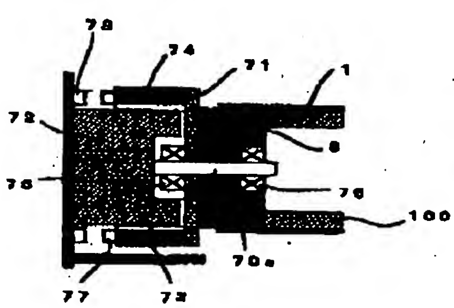
[FIG. 9]



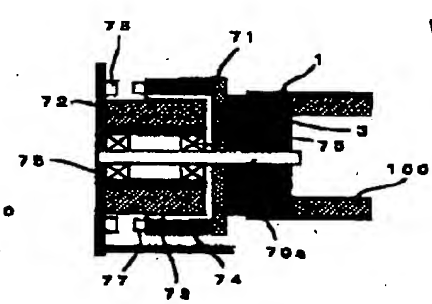
[FIG. 16]



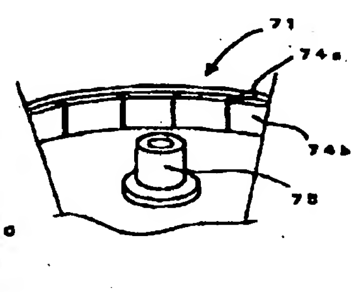
[FIG. 10]



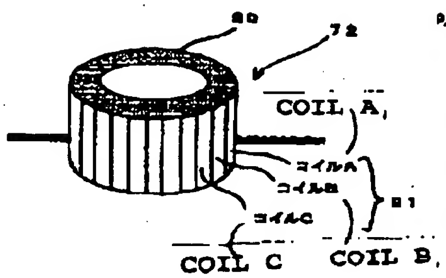
[FIG. 11]



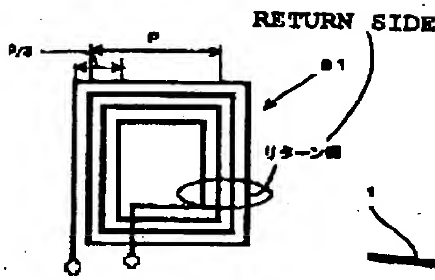
[FIG. 12]



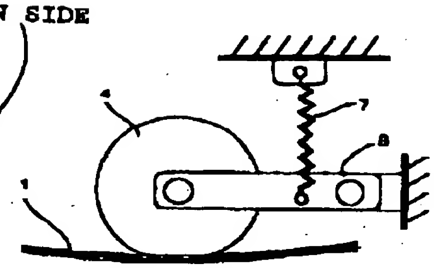
[FIG. 13]



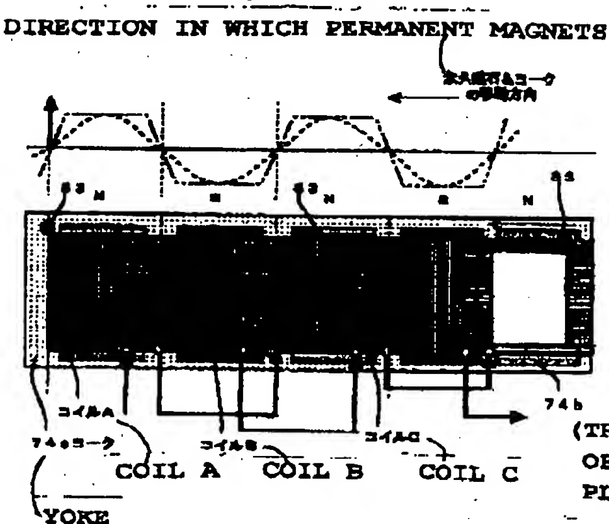
[FIG. 14]



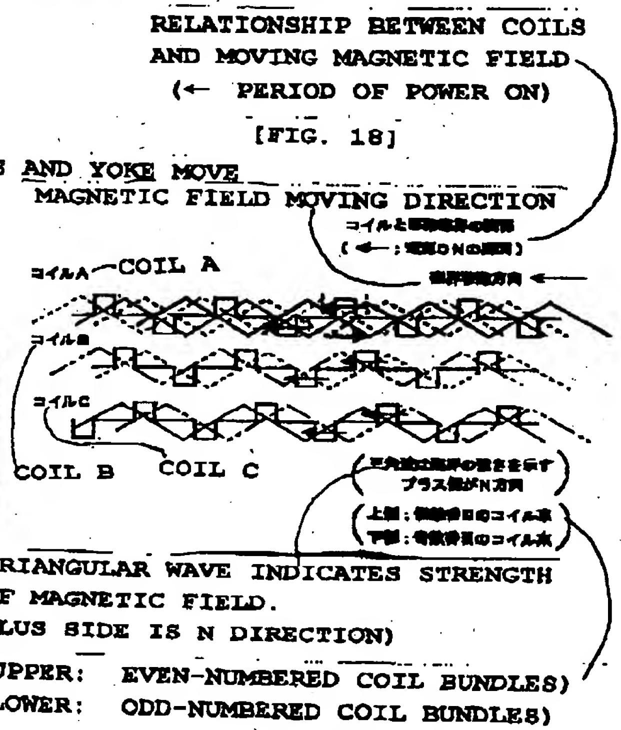
[FIG. 24]



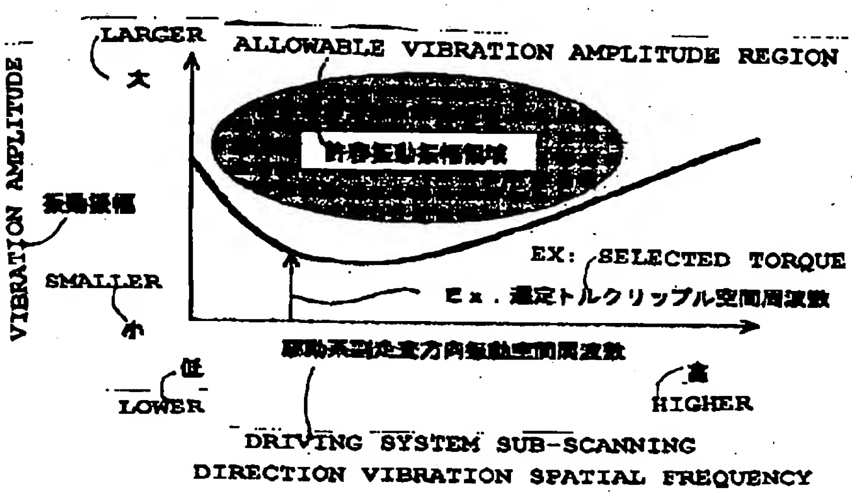
[FIG. 15]



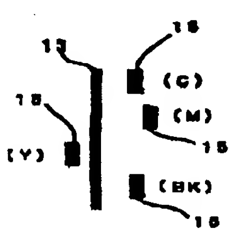
[FIG. 18]



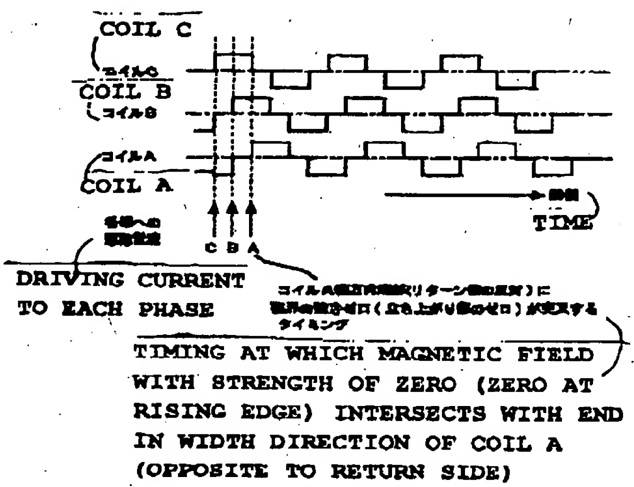
[FIG. 17]



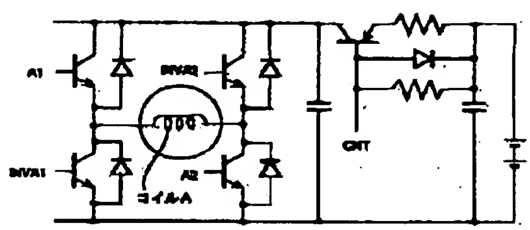
[FIG. 29]



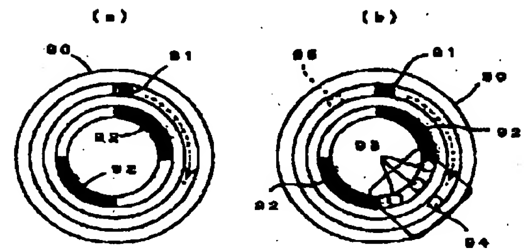
[FIG. 19]



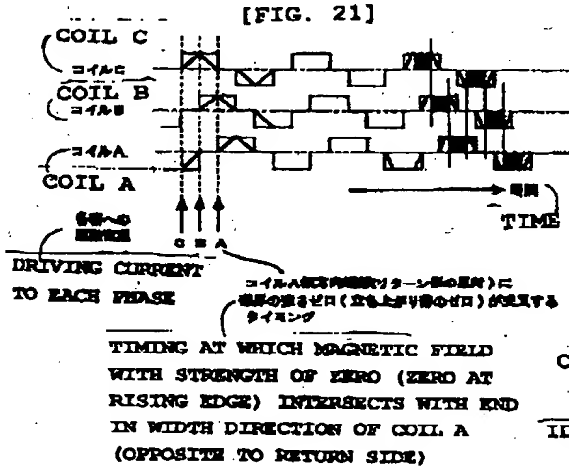
[FIG. 20]



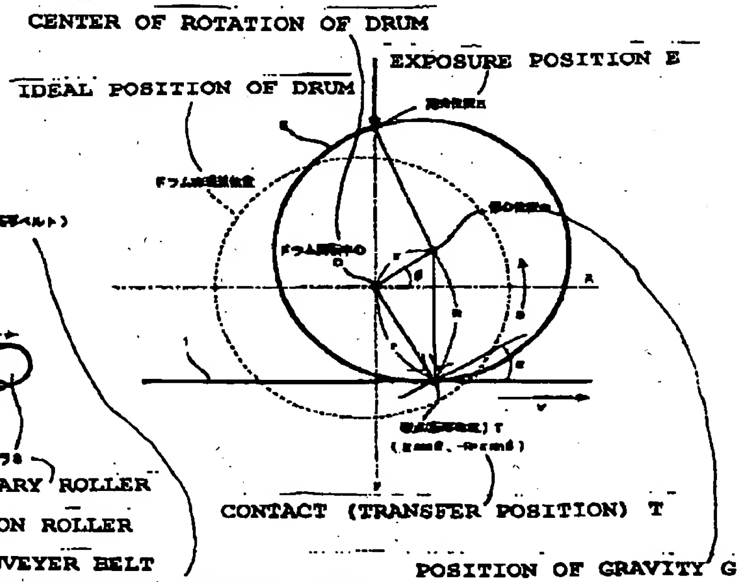
[FIG. 22]



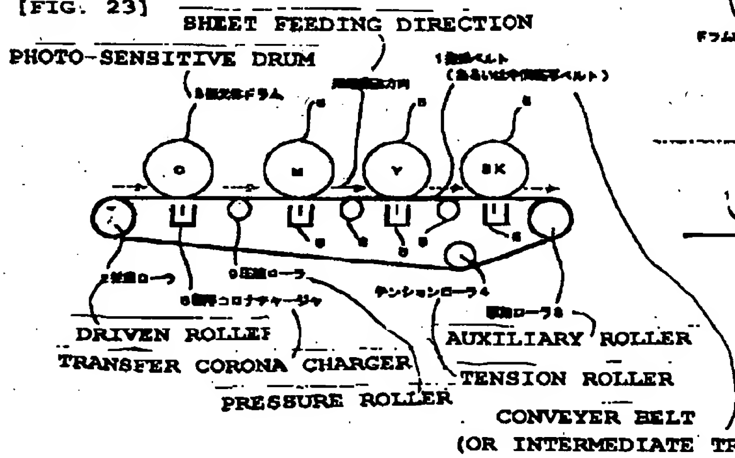
[FIG. 21]



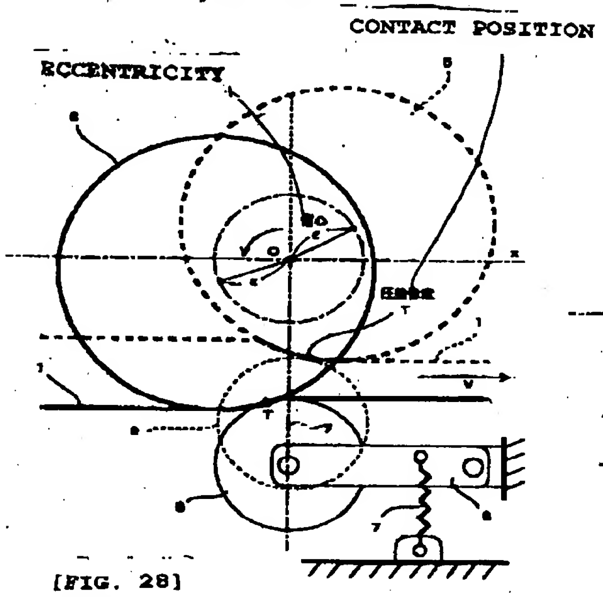
[FIG. 25]



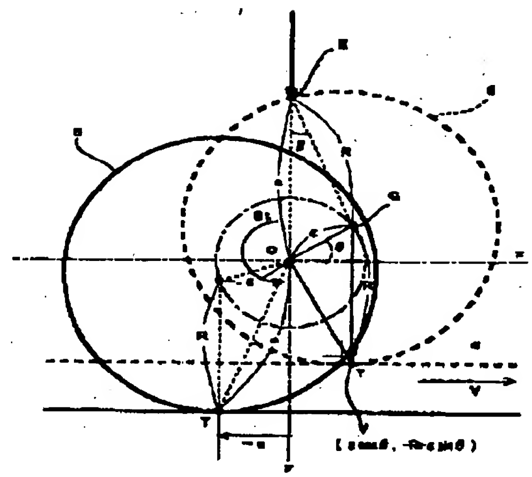
[FIG. 23]



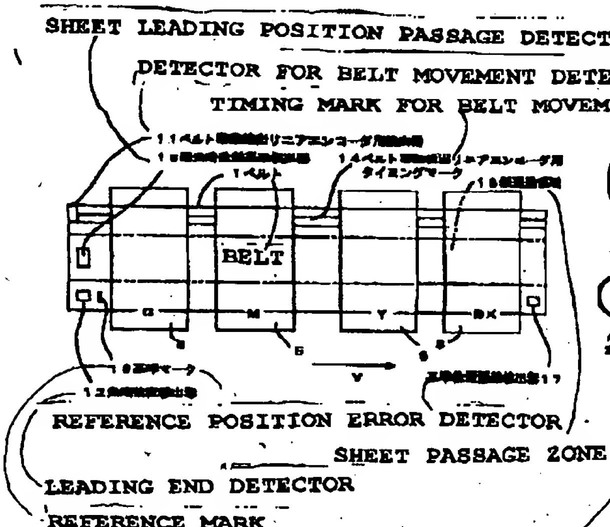
[FIG. 26]



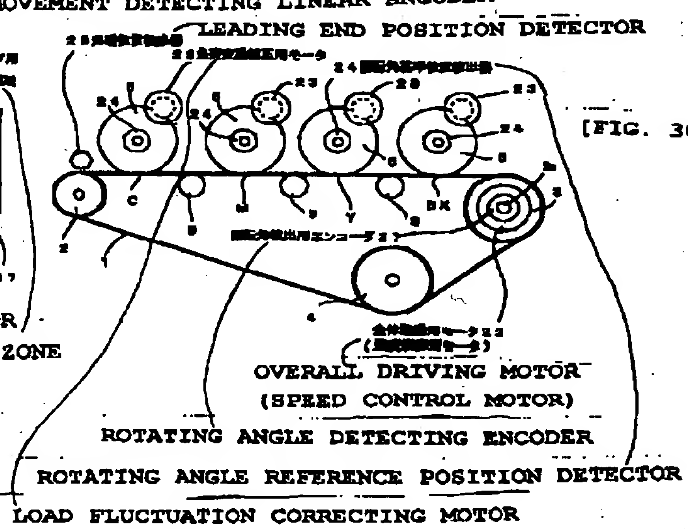
[FIG. 27]



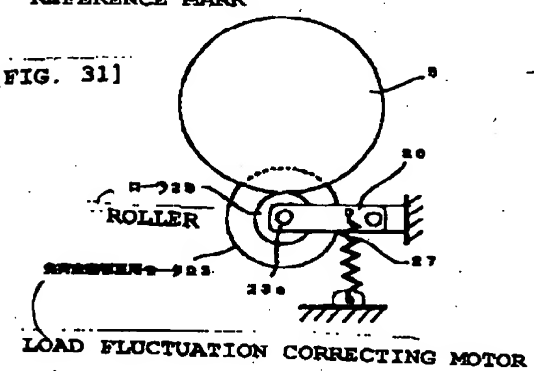
[FIG. 28]



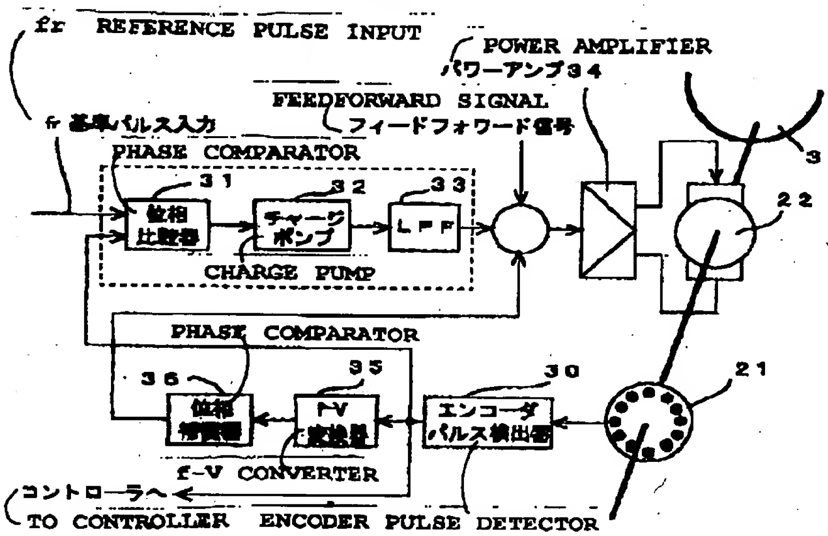
[FIG. 30]



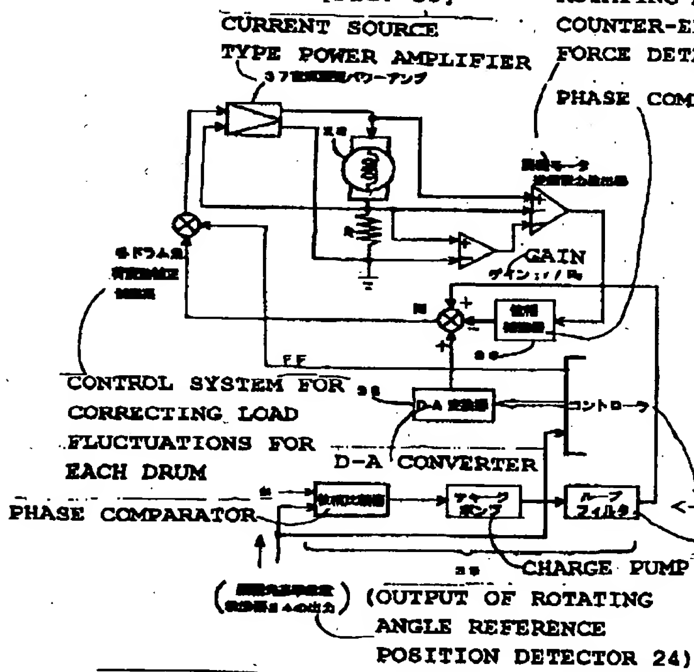
[FIG. 31]



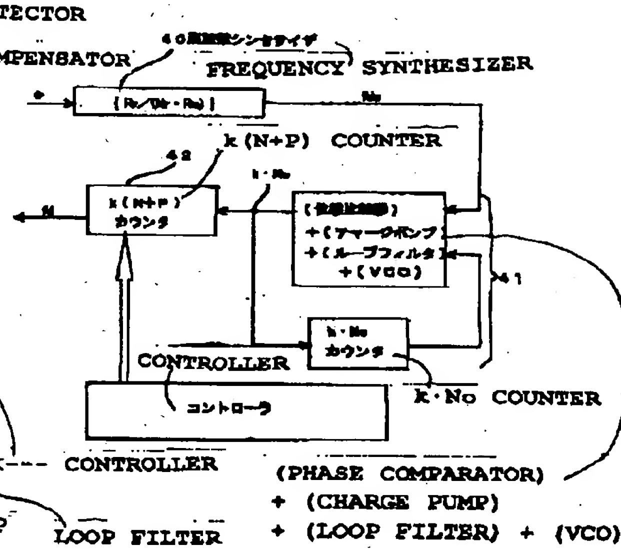
[FIG. 32]



[FIG. 33]



[FIG. 34]



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(51) Int. Cl.⁷	識別記号	F I	テーマコード゛(参考)
H02P 6/10		H02P 6/02	351G